COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC.

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RAILROADING AROUND THE WORLD

BY W. L. SAUNDERS.

A traveler who encircles the globe learns to appreciate the value of American railways. He also learns to prefer railway traveling, when long distances are concerned, to traveling in ships. One who visits Japan from the United States goes nearly half way around the globe, and if he is in a hurry to get home, appreciates comfort and likes to visit new scenes, he is better off coming home by way of Siberia, Germany, France and the Atlantic Ocean rather than to subject himself to the monotony of the broad Pacific. He also may save a few days, if he makes his connections.

The broad Pacific is interesting only in the contemplation of its expanse. No one can conceive of greater solitude than to be afloat in the Pacific Ocean. Its wave motion is usually moderate, with a broad expanse between the undulating crests. It is smooth on the surface and there are no signs of life, save an occasional flying fish, a rare encounter with porpoises and a whale now and then, whose antics are as welcome to the voyager as sunshine is to the Londoner in a November fog.

Recent railway construction and much improvement in equipment and operation add greatly to the comfort of the Trans-Siberian journey. Until recently one either crossed the Japan Sea, about a three days' journey, or took a more distant route to Port Arthur, and then made his way toward the Russian railways, but now it is simply necessary to travel by the Government railway of Japan to the extreme south of the Islands Shimenoseki, then across the narrowest body of water in that section which separates the Continent from Japan. This is a one night trip only, in comfortable boats, landing one at Fusan, Korea.

A word or two might be said of the railways in Japan. All the principal lines are owned by the Government, and this is always bad. It makes for inefficiency, bad management and lack of the best accommodations. Furthermore the railways in Japan are narrow gage roads, which seem to serve the purpose very well in a small country where the people are personally small in stature, and where furniture and accoutrements, such as we enjoy, are rare. These narrow gage railways are very well equipped for narrow gage railways. The trains go at considerable speeds and except in over night service one is reasonably comfortable.

The road from Fusan northward through the center of Korea is of broad gage with modified Pullman accommodations, under Japanese management, and an improvement on anything experienced in Japana. This road runs continuously through Seoul to Mukden, thence northward on the eastern Chinese Railway to the junction of the Trans-Siberian road at Harbin.

These railroads are patrolled by Japanese soldiers and operated by Japanese workmen. The soldiers do their duty in a manner above criticism, but it is evident that the Japanese are not naturally mechanical and that operating railroads is a service of great difficulty to them. They have in Japan, for instance, copied American and European types of locomotives, and so far as the reproduction is concerned it is perfect, but if anything goes wrong, if a connecting rod should work loose or a hot box trouble occur, the Japanese workman shows little initiative and skill. He is very apt to try the very same experiment he tried when a

previous trouble arose, though the causes may be quite different. I have seen six or eight men puzzled for an hour or more over a simple case of hot box, trying all sorts of remedies and showing a lack of clear knowledge of the theory of the trouble. A Japanese mechanic laboriously learns to do a certain thing, and when he masters it he can do that thing well, but if you shift him or introduce a new element in his work he is ill at ease. A simple illustration of this occurred on a Japanese railway where the clasp holding a lady's traveling bag was pulled out. Both the conductor and brakeman puzzled for at least ten minutes in an effort to repair the damage, when the lady herself (a girl of twenty years of age) impatiently took the bag from their hands and fixed it.

The Trans-Siberian Railway runs from Vladivostok to Moscow, a journey of from eight to nine days. The equipment, especially on the International train which runs once a week, is first class, with comfortable cars and good food. In the extreme east coal is burned in the locomotive, but as one reaches the interior of Siberia, where wood is plentiful, the engines are all wood-burning. The gage of this railroad is five feet, which adds to the size and comfort of the cars. The staterooms are large,—some with two beds and others with four. These cars are all of the Russian type, the same as used on the Nord express, which runs from St. Petersburg to Paris, and on the Orient express from Paris to Constantinople. The speed averages a little more than twenty-five miles an hour, generally about thirty, and at times even faster. Stops at stations are not as infrequent as one would suppose, but occur at intervals of two or three hours. The country itself is not a barren waste; there is no desert land in view, but it resembles Canada or a portion of the western United States. There are times that one could imagine the train going through the Coeur d'Alenes in Idaho, or northward through the Cobalt District in Canada. The country is rolling, mountainous only around Lake Baikal and at the Urals; there is much evidence of forests, burned for the purpose of clearing.

There is really less inconvenience, less friction and more real comfort of travel in a trip from Vladivostok to Moscow than from Paris to London. This statement is made deliberately by one who has had experience. Railway traveling becomes tiresome and excites one's nervous system in proportion as the trains wabble around curves, as the cars are crowded and as changes are required while making a journey. The little trip from Paris to London involves all the difficulties of travel. The trains in France and in England are always crowded. There is a rush to look after one's baggage, the cars are light, the tracks laid in curves, the speed high, and one is apt to reach the end only to find it necessary to scramble on to a little bateau with few, if any, comforts, and a passage by water which is either rough or extremely dull. On landing the same experience is repeated.

One learns to appreciate the Pullman car, which through its heavy weight, wide berth and open construction is supreme over anything abroad. While the road beds of Europe are fairly good, little irregularities are more plainly felt through the light equipment used there, hence car sickness is more frequent. The dining car service is satisfactory only in that the food is good. There is little variety about it as it is table d'hote and is served in a perfunctory manner, with a rush and clatter of dishes exceeding anything experienced in an American dinner.

AUTOMATIC STABILITY FOR AEROPLANES

It is stated in a London publication, that an engineer in India who has given close study to the question of aerial flight has made an important discovery regarding the equilibrium of aeroplanes. After many tests he has succeeded, it is stated, in securing an almost automatic stability in flight. A recent test was made in India with the invention fitted to an aeroplane model. The craft was cast into the air from a high point and it immediately floated, being influenced only by a gradual drop toward earth. The aeroplane moved quickly. It maintained its equilibrium throughout. It is claimed that the principle of the invention, if built into an aeroplane, would render perfect the "floating" of an air craft upon an "even keel" and would make toppling over or sudden dropping impossible. Sharp turns can be made also, it is said, and an accident to the motor is rendered of small importance. The details of the invention are a secret. The British War Office will be asked to test the contrivance.

THE AIR LIFT*

BY FRANK RICHARDS.

One of the most important, and now also among the most extensive and most rapidly extending employments of compressed air is in the so called "air lift," used for the raising of water and other liquids. This name is not correctly suggestive of the characteristics of the device, but it seems to be quite firmly fixed and no one seems to be able to supplant it with anything better.

The water-works of many towns and cities in the United States and elsewhere are entirely dependent upon the air lift, and its use for the obtaining of water from its natural subterranean sources is rapidly extending throughout the civilized world. It is used largely for the pumping of oil wells, for the unwatering of mines, and it handles semi-liquids, or liquids carrying a heavy burden of comminuted solid matter, with the same facility as clear water, making the water thus in many cases the cheapest conveyor available.

The adoption of the air lift for any specific service is seldom determined upon by considerations of power economy alone. It has its special adaptations to some exacting conditions, and it may be said to hold its own and to be continually extending its holdings by the fact that it can do work to which no other devices can be applied. The wide range of its employments, and its continuance in them is the best possible evidence that after all it pays. It is also free for anyone to employ it, as there can be no monopoly of the principle involved.

It is not necesary to make any mystery of the operation of the air lift, and no one has any privilege to pose as an exclusive repository of special information concerning it, although in the practical applications of it experience counts for more, and is more absolutely necessary than in almost any other field.

PRINCIPLE OF OPERATION.

The essential principle involved seems to be very simple and to be easy of explanation. Say that we have an open well, or in fact any body of water, so that it be deep enough and regardless of its volume or what may enclose it, a pond or lake or river being as good for our purpose as a well of whatever dimensions; and say that in this water is suspended or fixed a vertical pipe with open ends, the lower end extending a considerable distance below the surface of the water, the water being thus perfectly free to enter the pipe. Under the conditions, the water will rise to the same height inside the pipe as it is outside, and when the water levels coincide there will be nothing operative to cause any movement of the water either upward or downward.

If we wish to induce the water inside the pipe to rise higher than the water outside the pipe it can be done by reducing the weight, or more correctly, the specific gravity of the column of water as a whole contained within the pipe, and then the greater relative weight of the water outside the pipe will act to force the lighter column of water upward. The simplest way in the world to lighten the column of water in the pipe would seem to be to mix air with it, and this the so-called "air lift" does, and it is practically all that it does, while gravity does the rest.

Say that, with our pipe standing in the water as above assumed, and with the water standing at the same height within it as outside, a compressed air pipe considerably smaller than the other is run down alongside with its lower end turned up and reaching a little distance up into the large pipe, as in Fig. 1. In the placing of this air pipe it may be supposed that the water has entered it and has risen in it to the normal water level, if there has been no confined or compressed air in the pipe to oppose it. If now compressed air is turned on to the small pipe with a pressure sufficient to drive the water down to the lowest point in the bend of the pipe, the pressure required being determined by the height of the water surrounding the pipe and this pressure, 1 lb. for each 2 ft. (speaking loosely) of water depth, being the greatest pressure that will be called for in the operating of this particular lift, then as soon as the bend in the pipe is passed the air will escape upwards out of the air pipe and will diffuse itself through the column of water above.

We must not go too fast here. The air "lift" has not yet begun its lifting. The diffusion of the air through the column of water elongates the column of water upward but does not yet lighten it as a whole. The air might go on mixing with and diluting the wa-

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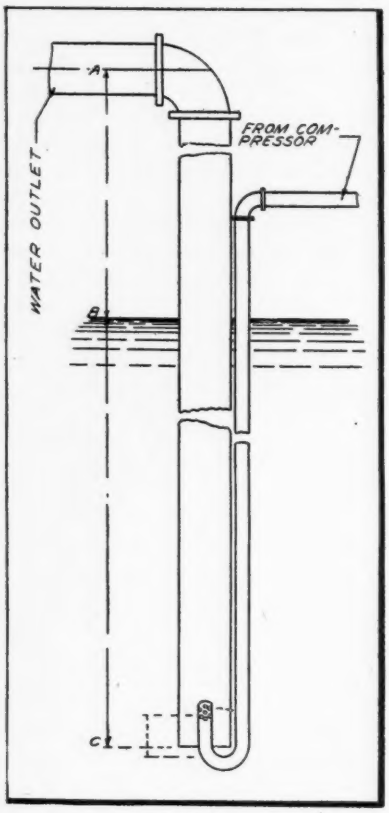


FIG. 1.

ter and gradually working its way up through it and finally, if the pipe was long enough, the the air would escape at the top of the column as fast as it was admitted at the bottom, but still there would be no "lifting" of the water by this operation alone. This gradual working of its way up through the water which the air thus does in the stationary column goes on also, but not so rapidly, when the column is moving and the lift is in full operation, thus constituting the "slippage" which seems to be one of the unavoidable sources of loss in the air lift.

As a matter of fact in the air lift the air does not work its way up through a column of water of unlimited length and escape out of the water at the top, leaving the water inert. Before this height is reached the water pipe ends and there is a continuous discharge of its contents. This discharge of the upper portion of mingled water and air at once reduces the weight of the column and then it begins to be pushed upward by the heavier solid water which is now able to force its way in at the lower end. The escape or discharge at the top makes the column continually lighter than is required to balance and entirely resist the in-pressing water below, so that the solid water continues to flow in, and then the entire column is kept rising and flowing off at the top, as long as the supply of compressed air is sufficient to maintain this condition of unbalanced pressure; and there we have the air lift complete. It is ultimately worked as we see entirely by the force of gravity.

It will be better to finish with the air and its career in the water before considering the action of the resulting unbalanced pressures. The levitation function of the air being understood, it will be evident that it must be desirable to have it mixed as intimately as possible with all the water in the column, so that here ingenuity and invention may play an important part in providing means for scattering the air and mixing it at the beginning all through all the water. If such scattering and intimate mixing of the air with the water does not occur at the instant of its discharge from the air pipe no such result can be possible later. It is to be assumed that the air will be distributed through the water in bubbles, large or small, and it is better that they should be as small and as numerous and as nearly as possible at uniform distances apart rather than to have them fewer and larger and irregularly distributed.

The originally propounded theory of layers of air alternating with pistons of water in the pipe represents an absurd impossibility. Whatever the number and size of the air bubbles at the beginning they will always be merging together to form fewer and larger ones. Whether the aerated column be stationary, as first assumed, or moving upward with the lift in full operation, the levity of the column which the air is employed to produce, will be determined by the amount of air actually distributed through it during the period of its upward passage through the pipe. If some of the air escapes by working up through the column, instead of moving with it, it represents power lost, and this loss will be greater with large bubbles than with small, because they will always float up through the water at the greater speed.

AIR USED ISOTHERMALLY.

In its operation the air lift uses the air expansively and gets the benefit of the expansion. When the lift is in full operation and the air and water mixture is flowing at a uniform speed through the discharge pipe there will be at any instant a given quantity of water and the equivalent of a given volume of free air. The air actually will not be either free air nor air at the full working pressure. When it is first discharged from the air pipe and mingles with the water it has already lost a small portion of its pressure, and as it rises with the column it will expand as the pressure due to the depth decreases, and it will be discharged with the water at a pressure little above that of free air. As the value of the air in the column is in the quantity of water it displaces this displacement will be greater per volume of free air at the top of the column than it will be anywhere below it. As the air is so intimately mixed with the water it must be assumed to take the temperature of the water, or its expansion may be said to be practically isothermal, which is as profitable to the user of the air when expanding as the absence of this condition is unprofitable when the air is being compressed.

Compressed air in the air lift, it has been seen, does not push or force the column of water upward after the lightening of the column, the latter being its only function, and the flow upward is caused by the unbalanced weight of the solid water outside and below the pipe. This suggests at once the necessity of maintaining a sufficient preponderance of pressure from the inrushing water, and this is only secured by the submergence of the pipe or its extension to a sufficient depth below the surface of the water. The height of the lift is the principal factor in determining the submergence required, the invariable condition being that the higher the lift the greater shall be the actual submergence.

As to this particular mistakes are often made. In planning an air lift for a bored and tubed well wherein the water does not rise to the surface but stands constantly at a certain distance below the surface, it is comparatively easy to compute approximately the submergence which should be adapted for delivering the water at a given height, experience rather than theory dictating the figures; but if when the pumping begins the height of the water in the well falls any considerable distance, as it often does, then the proportionate and the actual submergence may be quite inadequate. The submergence will be reduced as many feet as the surface of the water supply falls, and the lift will be increased an equal distance, a double-acting cause of inefficiency. In many cases where a new air lift is installed provision is made for lengthening or shortening the pipes to get the best submergence according to the developed working conditions which could not have been anticipated.

With a given submergence the lift may be greater or less, within wide limits, and the lift will still work, but there is for each case an approximate ratio of submergence to lift which gives the best results, both as to the volume of liquid raised and also as to the air cost, or power cost, of raising it. With a fixed submergence, whether the lift be proportionately small or whether it be as high as possible, the air pressure required will be the same, but while the pressure is thus determined by the submergence the actual volume of air per unit of time, and also the volume of water raised will be influenced and determined by other conditions, especially by the actual volume of air supplied and the resultant rate of flow of the water.

DETAILS OF THE AIR LIFT.

In computations upon the air lift the submergences are stated in percentages. The submergence percentage is that portion of the whole length of the discharge pipe which is submerged, the remaining percentage constituting the lift. Thus with a lift of 100 ft., if the submergence is 60 per cent., the lift, or 100 ft., will be 40 per cent. The 60 per cent., the submergence, will therefore be 150 ft., and the total vertical length of the water or discharge pipe will be 100+150=250 ft. In Fig. 1 A B is the lift and B C is the submergence, both being stated in percentages of the total length A C.

Attention is now directed to the chart or diagram, Fig. 2, from which may be readily determined the volume of free air required with different percentages of submergence to raise 1 gal. of water to different heights from 20 ft. to 1,000 ft. The data embodied in this diagram are practically the same, except in one particular, as the figures of a table given to the public two or three years ago by Mr. E. A. Rix, of San Francisco, who has done much in

various ways for general compressed air practice, the table having been compiled by Mr. Geo. H. Reichard of the same city.

The formula by which the table spoken of was computed, is as follows:

$$V=\frac{L}{\text{Log.}\frac{S+34}{34}\times C}$$

Here V is the volume of free air in cubic feet, this being taken in this case as the actual piston displacement o fthe compressor.

L is the lift in feet.

C is a constant, 234, unchanged throughout the computing of the table.

S is the actual submergence in feet, which is obtained as follows:

$$S=\frac{L\times sp}{lp}$$

sp being the submergence percentage and lp the lift percentage.

Say that the lift is 100 ft. and the submergence 60 per cent., then:

$$S=\frac{100\times 60}{100-60}=150$$

Using figures now in the original formula we have:

$$V=\frac{100}{\text{Log.}\frac{150+34}{34}\times 234}=0.584 \text{ cu. ft.}$$

For the air pressure required for any lift, and with any percentage of submergence it is convenient to divide the actual submergence in feet by 2 to get the gage pressure in pounds. This gives enough pressure in excess of that due to the water head to allow for the pipe-friction and other losses.

The one particular in which the computations for our diagram differed from those for the Rix table spoken of was in the constant C. This, as indicated by the line in the upper part of the diagram, instead of remaining the same, 234, all through, was made to decrease gradually as the lift increased. Thus for a lift of 200 ft, our constant is 235, practically the same as that used by Mr. Reichard, but for 100 ft. lift it is 245, for 500 ft. it is 200, and so on. The result of this change is to increase more rapidly the free air per gallon as the lift increases, which seems to agree better with observed results.

The line for constant C in the diagram follows very closely the figures given by Mr. H. T. Abrams, air lift expert of the Ingersoll-Rand Company, in a lecture at Columbia University.

The most striking thing observable in an examination of this diagram is that the volume of free air required per gallon of water lift constantly decreases as the submergence increases. Thus at 25 per cent. submergence and 200 ft. lift, the free air required per gallon is 1.83 cu. ft., while for the same lift and 60 per cent. submergence the free air is 0.88 cu. ft., or less than one-half. In the first case, however, the air pressure required is about 17 lbs., gage, while in the other case the pressure would be 75 lbs., and the mean effective pressure required for the compression of the air (adiabatic) to 17 lbs., would be about 13 lbs., while for compressing to 75 lbs. the mean effective would be 35 lbs. Then comparing $1.83\times 13=23.79$ with $0.88\times 35=30.80$, it appears at once that the apparent cheapness of deep submergence is nullified or reversed, and other considerations determine what submergence is best.

The air lift is intended for steady work and not for occasional and frequently intermitting service. It is not to be stopped and started at any odd time like a common reciprocating lifting pump. Its efficiency is largely influenced by the correct adaptation, or otherwise, of the sizes of air pipe and discharge pipe to each other and to the rate of air delivery, the latter being entirely controllable, while the inflow of the water adjusts itself to the conditions provided. Nothing is thought of here but the relations of discharge pipe and air pipe to each other, it being assumed temporarily that the water is free to flow into the bottom of the discharge pipe as the "air lift" takes it away. The speed of this voluntary (as we may call it) and uncoercible flow of the water really determines the best working speed, and

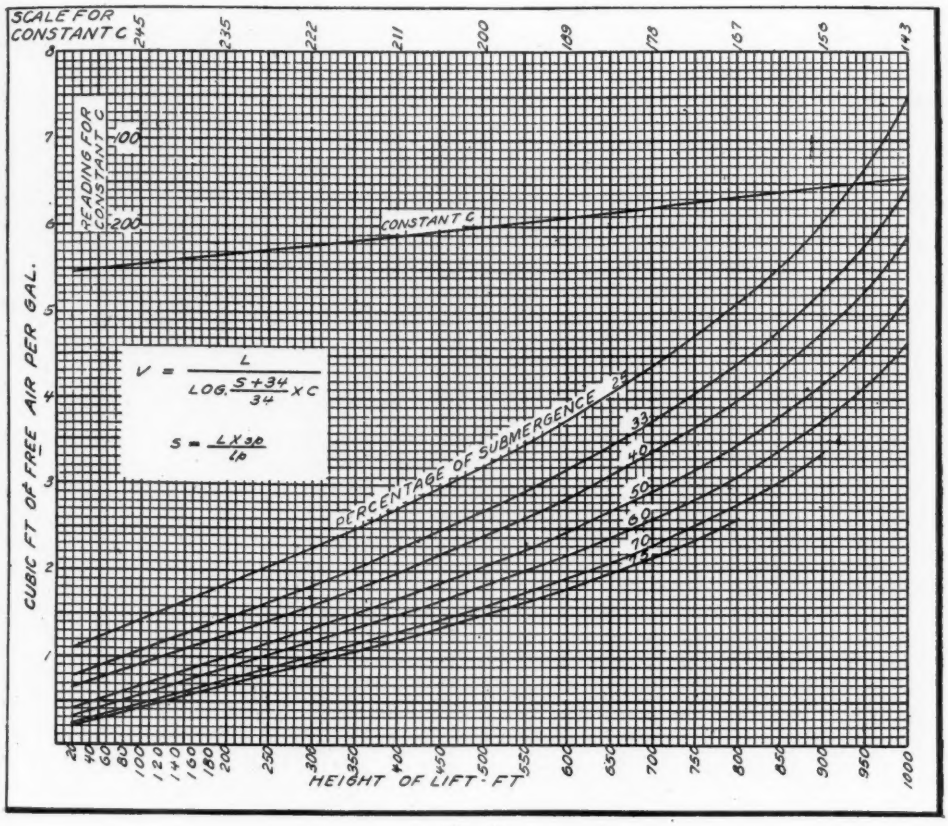


FIG. 2.

also, within certain limits, the possible working speed of the air lift. As might naturally be supposed, the rates of flow in the pipes and the corresponding actual deliveries of water will be more rapid for the low lifts and small actual submergence than for the high lifts and deep submergence, the greater length of pipe causing the greater retarding friction.

While from what has been written above it would seem that almost anyone might install and operate an air lift, there is probably no application of compressed air in which experience counts for so much, and it is recommended that in all cases a competent expert be consulted or employed. In this view of the case it does not seem worth while to lengthen this article by the insertion of tables of pipe capacities and other working data, as these may be obtained from builders of air compressors and others in touch with the business.

LARGE BLAST IN AN OREGON QUARRY

One of the largest shots ever fired in Oregon, for the purpose of securing stone for road building was fired on December 31, 1911, at Kelley Butte Quarry. The charge was placed in a tunnel and laterals were driven into the quarry face, the entire system having a length of 160 ft. Six tons of Special Red Cross quarry powder, divided into eight charges, were placed in the tunnel and were fired by electric exploders, the battery being about 1,000 ft. from the blast. The stone is a cubical basalt, standing upright, with vertical seams, and while comparatively easy to bring down is hard and tough and well adapted to road building. The blast brought down about 30,000 cu. yds. of stone, which is stated to be enough to provide crushed rock for 15 miles of standard macadam road and to keep the crusher plant at the quarry running for a year.

ARTIFICIAL MOUNTAIN AIR

In any large party of tourists who have reached the summit of a lofty peak without effort, by the aid of a modern mountain railway, there are usually a few persons who do not share the general enthusiasm and exhilaration, but lean heavily on their alpenstocks and evidently feel uncomfortable and oppressed. The ascent of a snow-clad peak on foot sharpens the appetite of all true mountain climbers, but it produces the opposite effect on certain individuals.

In both cases the abnormal symptoms are those of mountain sickness, which may be defined, in a general way, as the inability of the organism to adapt itself promptly, or at all, to changes in external conditions. At the extreme heights attainable in balloon ascensions the strongest of men are subject to this disability. Hence it is possible to classify persons according to the heights which they can attain without being affected by mountain sickness, but this classification cannot be absolute because the susceptibility varies with the general condition of the organism.

At one time mountain sickness was supposed to be caused chiefly by the fatigue of mountain climbing, combined with the influence of wind, atmospheric electricity and other climatic factors. This view was apparently supported by the fact that the morbid symptoms are alleviated by rest in sheltered situations, but most diseases are palliated by similar treatment. It was observed, furthermore, that such characteristic symptoms as insomnia and changes in the pulse and respiration often occur in persons carried to great heights without any bodily exertion. More importance, therefore, was attributed to the changes in external conditions, and especially to the diminution in atmospheric pressure at great altitudes and the corresponding diminution in the supply of oxygen. Each of these factors has been made the basis of a theory of the causation of mountain sickness.

In a recent issue of *Die Umschau* Dr. David expresses the opinion that the discomfort which many persons experience at great altitudes is caused chiefly by the diminution in atmospheric pressure. For most persons according to this writer, a sojourn in mountain regions at altitudes up to 10,000 feet is wholly beneficial, and the benefit is due partly to objective and determinable factors and not entirely to the subjective influences of change of scene, environment and occupation.

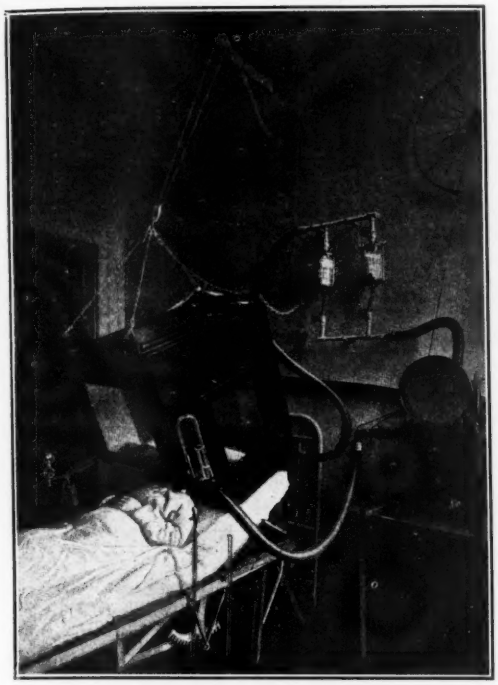
The character of the respiration, for example, is altered. Observation shows that at great altitudes and, in general, in an atmosphere poor in oxygen the volume of air inhaled and exhaled in each respiration is increased, while the number of respirations per minute remains unchanged. In this way a more thorough ventilation of the lungs is effected without greatly increasing the work done by the respiratory muscles. This involuntary, unconscious and effortless deep breathing is quite different, in its character and effects, from deep breathing practised laboriously under an effort of will, which may seriously overtax the heart.

It has also been discovered that the red blood corpuscles, the oxygen-carriers of the body, become much more numerous in the atmosphere of the mountains, and that this increase of these short-lived corpuscles is due to a more rapid production, not to a less rapid decay. The parts of the spinal cord in which these corpuscles are generated reveal, under the microscope, evidence of increased activity.

The deficiency of atmospheric oxygen probably stimulates other organs than the spinal cord to similar compensating activity, and Dr. David regards such stimulation as very beneficial, if not carried to the point of exhaustion. It is for this reason that mental workers are refreshed by moderate indulgence in walking and athletic sports, while men engaged in hard manual labor derive physical benefit from reading and other mental work. In each case comparatively idle cells are forced into action.

This stimulating effect of mountain air is revealed by the balance sheet of bodily receipts and expenditures. It has been found that if the albumen ration which is required to keep the body in normal condition at the sea level is consumed in the mountains the result is an accumulation of albumen, the most important constituent of the muscles and most of the organs.

The theory that the beneficial effects of mountain air are due to its poverty in oxygen receives additional support from Dr. David's discovery that the circulation of blood through the lungs of animals is increased by diminishing the proportion of oxygen in the atmosphere.



ARTIFICIAL MOUNTAIN AIR.

Certain pulmonary disorders in which the lungs are imperfectly expanded and ventilated, and some diseases of the blood in which the formation of new cells is sluggish are characterized by depression of the functions which are especially stimulated by a deficiency of oxygen in the atmosphere. In order to produce this deficiency of oxygen without the diminution in pressure to which Dr. David attributes mountain sickness, he has devised the apparatus herewith illustrated.

The patient's head is inclosed in a large air-tight box provided with glass windows and with a rubber collar so constructed that it makes an air-tight joint about the neck without producing uncomfortable pressure. The box is suspended in such a manner that it can be placed in any desired position. An electrically driven blower and a pair of wash bottles are connected with the box and each other by rubber tubes, forming a closing circuit in which the air circulates continuously, being freed from the injurious products of respiration by its passage through the wash bottles.

By means of a specially constructed valve, shown on the opposite side of the box, and connected with a reservoir of oxygen, a quantity of oxygen exactly equal to the quantity consumed in respiration is continuously admitted. The proportion of oxygen in the air can be reduced to the desired degree at the outset by drawing off some of the air and admitting nitrogen or some other inert gas through this valve, or gradually by connecting the nitrogen reservoir with the valve without drawing off air so that the oxygen consumed is replaced by nitrogen.

The ordinary atmospheric pressure is maintained in the box. The composition of the air may be determined, from time to time, by the ordinary methods of gas analysis, or a self-registering apparatus may be constructed to give a continuous graphical record of the proportion of oxygen. An air-tight cabinet which the patient can enter and in which he can move freely may be used to advantage instead of the box surrounding the head. A cabinet of this sort will soon be installed in a German sanitarium.

The results of the therapeutic applications of this apparatus that have been made, thus far, appear to corroborate the theory on which it is based. It does not aspire to rival the Alps, but is designed merely to produce some of the beneficial effects of mountain air without its disadvantages, especially in cases in which great altitudes are positively contra-indicated.—*Scientific American.*

THE SPROUTING OF A GREAT PLANT

The following, by E. J. Edwards, is from "New News of Yesterday," in the Evening Mail, New York. It is presented here for whatever it may be worth, and it is at least worth reading.

Shortly after the Civil War Samuel Ingersoll [his name was Simon] of Stamford, Conn.—the first man in America to adapt a motor to a wagon—[which is doubtful]—chanced to meet on a railway train between Stamford and New York City a contractor who complained of the delay on an important job by the difficult character of some of the rock-cutting to be done. Finally the contractor said:

"Ingersoll, you have done a good deal of inventing. Now, I wonder whether you cannot invent a machine which will take the place

of hand labor in drilling rocks? I don't see why it cannot be done."

Ingersoll seemed for a moment completely absorbed in an idea that had suddenly come to him. At last he said:

"I think I see a way by which I can make exactly what you want. You want a machine driven by power which will drill holes rapidly in rocks."

"That is exactly what I want," said the contractor. "And I'll tell you what I'll do with you. If you will make a machine of that kind, and show me the model so that I can see how it works, I will, if it is satisfactory, give you $100 for it."

"I'll do it," Mr. Ingersoll replied; and in the course of two or three weeks he carried to this contractor not merely the model of his apparatus, but one which had been actually built and was ready for service. A thorough test was made of it. Certain improvements were suggested and adopted, but the fundamental idea of the invention—Ingersoll's original conception—has been preserved from that day to this.

This rock drill is one of the inventions of the last half of the nineteenth century, which have served to change the face of the globe by opening up regions to civilization which were at the time of our civil war practically unknown. It made possible the very rapid railway construction in the mountainous districts of this country which began shortly after the close of the civil war. But for it the Panama canal would not now be nearing completion with such startling-like rapidity. It enabled New York to secure a new water supply from the heart of the Catskill mountains, to cut a tunnel through the solid rock a thousand feet below the surface of the Hudson river in little over a year's time.

It has been estimated by competent engineers that the rock drill has increased the wealth of the world within the past forty years by hundreds of millions of dollars. More than one leading engineer of the world has linked Mr. Ingersoll's name with that of George Westinghouse, that of Sir Henry Bessemer and that of Thomas A. Edison—all inventors of apparatuses which have been able to consummate colossal constructive triumphs in the last half century. The only money Samuel Ingersoll ever made out of his greatest achievement was that insignificant $100.

THE AIR COMPRESSOR AND THE DIESEL ENGINE

The air compressor is an important and responsible auxiliary of the Diesel engine, especially when the latter is employed in marine propulsion. The following is a brief sketch of the motor equipment of the Selandia, which we suppose should be called an "oiler" instead of a "steamer," built in Denmark and recently started on its first voyage to Siam.

The main engines, built, like the vessel itself, by Burmeister & Wain, of Copenhagen, consist of two sets of 4-cycle Diesel motors, each with eight cylinders 20.8 by 28.7 inches, giving together 2,500 indicated horsepower at 140 revolutions per minute. At first sight their general appearance resembles that of ordinary reciprocating steam engines of the inverted marine type, but on inspection differences are quickly revealed, such as the closed-in crank pit and the long valve rods which stretch up from the valve gear to operate the four valves —air admission, fuel oil, starting, and exhaust —that are placed on the tops of the cylinders. The cam shaft, which actuates the valves, is driven at half engine speed through a small spur wheel on the crank shaft, which gears into a larger wheel mounted on an intermediate shaft. This latter, by means of cranks and connecting rods, drives a second shaft placed higher up, which in turn, by gearing, works the cam shaft. For each cylinder there are two sets of four cams; and according as one or other of these sets is in contact with the valve rods the direction of the motion is ahead or astern. When the engine is at rest the valve levers stand in an intermediate or neutral position clear of the cams, but when a start has to be made the cam shaft is moved an inch or so longitudinally to the right or left according to the direction of motion required and the valve levers are dropped upon the cams by a small compressed-air engine mounted on the front of the engine casing. Reversing from full speed ahead to full speed astern can be accomplished in less than 20 seconds.

Compressed air, at a pressure of 300 pounds per square inch, is also used for actually starting the engines. While the cam shaft is being got into the proper position the starting lever is in the neutral notch. It is then moved forward, admitting compressed air to the cylinders, and when the engine has attained the necessary

speed, fuel oil is admitted by moving it still farther forward, the starting valves then closing themselves automatically. The amount of oil, and therefore the speed, is determined by the position of the starting lever in a series of notches at the back of the quadrant. The oil is forced into the cylinders at a pressure of something like 1,000 pounds per square inch by a pair of pumps placed above the starting lever, each pump serving four cylinders, and it is taken from a couple of service tanks in the upper part of the engine room casing, to which it is raised by a pump driven by compressed air. Each of these tanks holds sufficient for 12 hours' normal work. An Aspinall governor is fitted to cut off the oil from the cylinders should the speed of the engines become excessive, as by racing of the propeller.

For lubrication, oil is pumped through the main bearings, crank shaft, connecting rod brasses, connecting rod, cross-head brasses, and piston rod to the top of the piston rod, whence it is returned through the piston rod and is ejected upon the guide faces. These being cooled by the water circulation, it is there cooled, and if further cooling is required it can be pumped through an oil cooler. A special lubricating arrangement is provided to supply oil to the surface of the pistons.

For furnishing the necessary compressed air there are two three-stage compressors, one behind each of the main engines, driven by two auxiliary Diesel engines having four cylinders and developing 250 horsepower at 230 revolutions per minute. These deliver air at 300 pounds per square inch, which is stored in four large cylindrical tanks. For injecting the fuel air is taken from these and raised to 900 pounds pressure by compressors fitted at the forward end of the main engines and driven from the crank shafts. Either of these compressors is able to provide sufficient for both main engines, but to meet the emergency of both being out of order, there is a Reavell compressor driven by steam obtained from a small donkey boiler. This is fired with oil fuel, and also serves for heating the radiators in the ship. Finally, arrangements are made so that the exhaust valve of one of the cylinders of the main engines can be removed and replaced by a delivery valve; that cylinder then acts as a compressor, if the fuel be cut off from it, and delivers air at 300 pounds pressure. Evidently, therefore, the total failure of the compressed-air supply is an exceedingly remote contingency.

Besides driving the air compressors the two auxiliary Diesel engines each work a dynamo generating current at 220 volts. For lighting purposes this is transformed down to 110 volts, but it is used at its original voltage for driving most of the auxiliary machinery, including two pairs of lubricating pumps, circulating water pumps, hot and cold water sanitary pumps and bilge pumps, a carbonic acid refrigerating machine, the capstan, all the winches on deck, and the steering gear, which is on the Hele-Shaw Martineau system. Compressed air is employed for the ballast pump, and also for the siren, being taken for the latter purpose from the second stage of the main compressors at a pressure of about 120 pounds.

QUICKEST TRAIN BRAKING

The quickest way for a person in a car of a passenger train to cause the stoppage of the train is to exhaust air pressure from the brake pipe, and for this the conductor's valve is provided. To neglect this means, and, instead, to signal the engineman to stop, interposes an appreciable delay. This is wholly unnecessary, if the men in the cars are competent to manage the conductor's valve; and in case of a danger which demands the quickest possible stop the delay may mean an aggravation of the danger; in other words, it may be important to reduce the delay as much as possible. We have long since abolished the uncertainties of the old bell-cord, but we have not done away with its slowness. With the air signal there must be an interval between the two blasts of the whistle, and another interval to enable the engineman to assure himself that the signal does not mean something else than "stop." And with a fast train every second is precious. These considerations are illustrated in an accident which happened recently to one of the fastest trains on an eastern trunk line. The electric light dynamo under one of the cars became loose and dropped so far as to catch on the plank at a highway crossing, which resulted, after running a few hundred feet, in the dynamo being thrown out to one side and across the adjacent main track. The two trucks next back of this dynamo were badly damaged, but did not run off the track. Riding in this car was the conductor of the

train, and, feeling the severe jar, he grasped the whistle cord and gave the two pulls necessary to convey to the engine a stop signal. Seeing that the engineman did not respond, he gave two more blasts; and then instructed the porter to pull the conductor's brake valve, which was done. But the disturbance caused by the accident was also heard or felt by a brakeman in the next car in the rear, and he also pulled the whistle cord twice; and these two pulls, coming between the first two and the second two given by the conductor, made six in all, and six blasts of the whistle was what the engineman received. This is the signal for increasing the supply of steam to the heating pipes, and that was what the engineman did. The whistle was blown a seventh time, however, and so the engineman, although on looking back he could see nothing wrong, concluded that something was the matter, and applied the brakes. By this action, or that of the porter, the train was stopped. From the time that the conductor first pulled the whistle cord it ran a mile and a quarter.—*Railway Age Gazette.*

A COMPRESSOR KICK

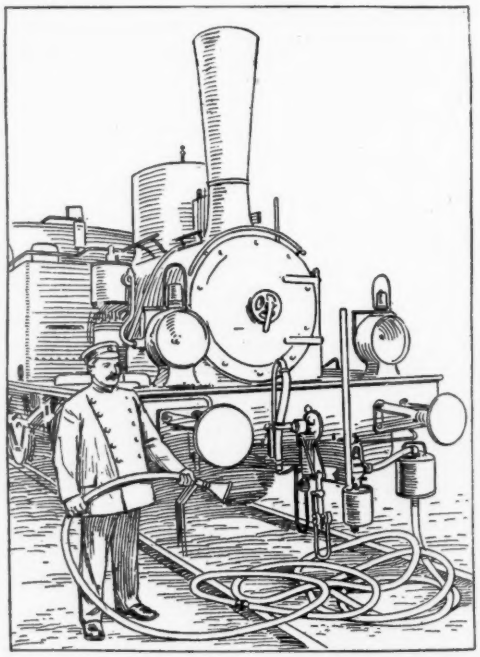
We have in use an old compressor which had punched a hole through the air cylinder head about 4 in. diameter, and this had been closed by bolting a plate over it. One day a slight leakage appeared around this plate and I said to the youngster, "John, put a new gasket under that plate when we shut down." Accordingly, at the noon hour, John took a wrench, removed the cap screws that hold the plate, and, standing directly behind the plate, started with a chisel to pry the thing loose.

Right there things happened rapidly. When John found himself he had displaced a large pane of glass in the window just behind him and was wedged in so tight that it took both of us to get him out. When he came to himself, his first remark was, "Who'd a thought that that little plate could kick so hard?" The trouble was a leaky discharge valve, which let pressure back up from the receiver tank into the compressor cylinder, and I noticed that whenever anybody afterwards had any repairing to do on the compressor, he let the pressure off the receiver before starting on the job.—*Practical Engineer.*

A LOCOMOTIVE VACUUM-CLEANER ATTACHMENT

An apparatus by means of which a locomotive is converted into a vacuum-cleaning plant is shown in the accompanying illustration. It comprises simply a suction chamber attached to the injector valve of the locomotive, a steam trap for the condensation of water, a dust collector, which is kept partially filled with water, and the necesary amount of hose and types of suction tips or nozzles. The steam trap and dust collector are connected by means of a hose of large diameter, and the suction hose is attached to the bottom of the dust collector.

When the injector valve is opened the live steam passes the opening of the suction chamber and creates a vacuum therein, which produces the suction, drawing the dust and dirt into the dust collector where it is retained by the water. The air, after unloading its burden of dirt, then passes into the steam trap and is exhausted into the atmosphere. With a sufficient length of hose, several passenger coaches can be vacuum cleaned by simply backing the locomotive up to one end. The apparatus is used on one of the German railways. —*Popular Mechanics.*



A RAILROAD VACUUM CLEANER.

A COMPRESSED AIR GROUTING MACHINE FOR GROUTING TUNNEL LINING

Fig. 1 shows the essential details of a grouting machine in which the grout is mixed and from which it is ejected by compressed air, while Fig. 2 shows a battery of these machines at work grouting the concrete lining of the Walkill Tunnel, which is one of the pressure tunnels in the Catskill aqueduct being built to supply water to New York City. The specifications for these tunnels provide that all larger voids behind the concrete lining shall be dry packed and that minor voids and crevices shall be filled with grout either through pipes built into the lining wherever need of them can be foretold, or through holes drilled after the lining is placed. The proportions of the grout mixture is to be determined by the engineer, but the character of the sand is specified: "It shall be clean sand of such fineness that 100 per cent. will pass a sieve having 64 openings per square inch and 45 per cent. will pass a sieve having 1,600 openings per square inch.

There is a cylindrical steel tank with a conical hopper bottom and a flat top having a charging door. The charge of cement, sand and water is placed in the tank and the compressed air is directed through the bottom, running upward through the material and mixing it by agitation. When the batch has been sufficiently mixed the air pressure is diverted into the top of the mixer and passes the grout out through the discharge pipes, whence it is delivered by hose to the cavity being grouted.

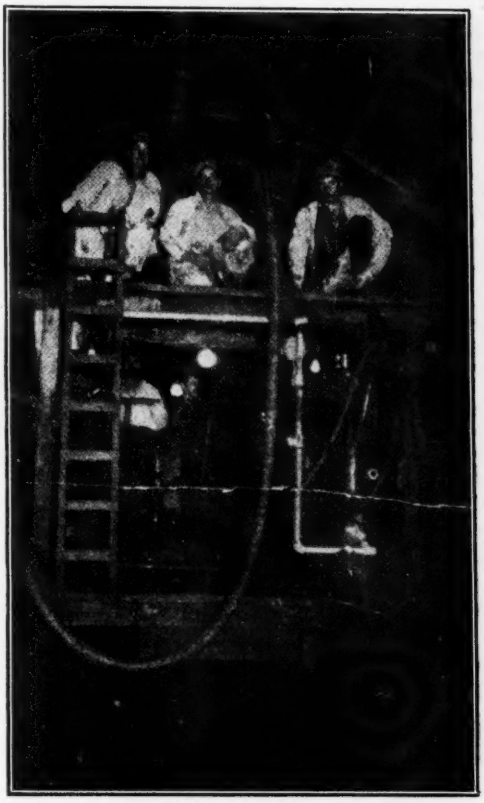


FIG. 2.

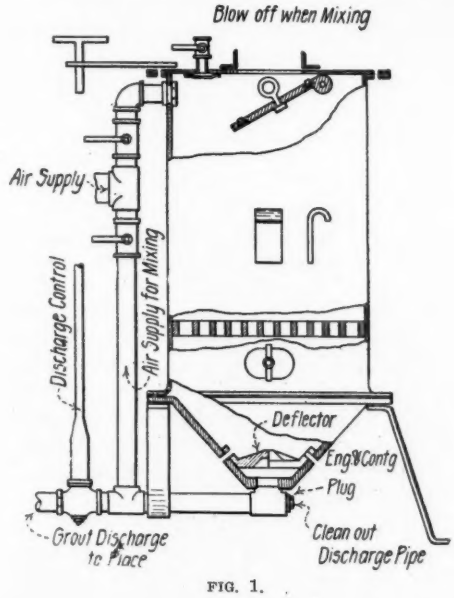


FIG. 1.

In the Walkill tunnel a special outfit of mixers was installed by the Degnon Company, contractors. It consists of four Ransome-Canniff grout mixers and an air compressor set up on a heavy platform on wheels. The mixer nearest the compressor is used exclusively as an air receiver. The other three mixers are connected up in a battery, but the end one is so connected that it can be shut off from the other two mixers and used separately. By this arrangement the three mixers can work together under any pressure up to 300 lbs., and if necessary the end mixer can be cut off from the other two and worked separately under 300 lbs. pressure, while the other two mixers continue to eject under 75 and

100 lbs. pressure. This has resulted in a large saving of time and expense. It should be added that the rear end of the platform is used to pile bags of cement upon and from this point the cement is emptied into the three hopper-like affairs above each mixer. With these grout mixers the contractors are grouting 24 hours a day divided into three 8-hour shifts, and an average of 200 or 300 lineal feet of tunnel has been grouted per day.

On the Rondout pressure tunnel grouting is also in progress, using the same type of grout mixers; a battery of three mounted on a car is connected up to two 9½x5x10-in. air compressors. The compressors are used to raise the pressure to 350 lbs., when necessary, the normal direct-line pressure being only 100 lbs. An air reservoir made of a piece of 12-in. wrought iron pipe 5 ft. long is used between the compressor and the tanks. The grout used was generally a 1 to 1 mix with sufficient water to lift it into place.

The grout mixer described is known as the Ransome-Canniff mixer and is manufactured by the Ransome Concrete Machinery Co., Dunellen, N. J.—*Engineering and Contracting.*

COMPRESSED AIR PLANT FOR MINES

BY LUCIUS I. WIGHTMAN.

Of recent years a noticeable tendency in mining work is toward the adoption of air compressors of high economy, both for coal and for metal mining service. At first thought it would not appear necessary for the operator of a coal mine to consider fuel economy seriously, but the facts in the majority of cases are to the contrary; and even where the cheapest grade of coal is used as fuel at the coal mine, managers are taking care to make it go as far as possible by means of high-efficiency steam-driven compressors.

Increasing use of high-duty compressors in the metal mining industry is the direct result of the exhaustion of rich ore bodies and the necessity for mining and treating low-grade ores which would have been considered not worth handling a decade ago. The prevailing low market price of metals, coupled with this steady movement toward large-volume, low-grade production, has forced mine managers to apply the best cost-reducing methods to their operations. And since compressed air is the main reliance of the mine operator, he is giving closer attention to the problem of more economical air compression, to be realized only by the adoption of the most up-to-date and efficient compressor types. His problem is further complicated by the high cost of fuel prevalent in most metal mining districts. And even where electric power is available for mine service, the rates are usually so high as to demand every effort toward utilizing to the utmost each electrical horsepower delivered to the compressor shaft.

FEATURES OF THE STRAIGHT LINE COMPRESSOR.

This type of compressor, because of its simplicity, compactness, ease of transportation and installation, and "fool-proof" quality, will always find a place for development work in new properties. Some builders are manufacturing straight line compressors with high-duty features, such as compounded steam cylinders and even Corliss steam valves; and compounded air ends are so common as almost to call for no comment. But the difficulty of getting economical regulation under widely varying load, such as is characteristic of mining work, without flywheel interferes with the economical refinement of such machines. Above 75 or 80 per cent. load it may realize the fuel economy to be expected from steam compounding and be economically self-regulating; below this limit it must either be regulated by hand or be left to blow off excess air through the safety valve, so that the double-tandem-compound compressor, whether either Meyer or Corliss steam valves, is but little more efficient on partial loads than a simple steam machine.

DUPLEX COMPRESSORS FOR MINES.

Duplex compressors are rapidly dominating the field of mining service. The best modern duplex double-compound compressor maintains practically a uniform fuel or power economy over a wide load range, and will, because of its quartered cranks, run down to a low speed with only the slightest departure from the best efficiency. Where a maximum compressed air capacity must be instantly and automatically available, with an average daily load factor of around 50 per cent. and probably less, the duplex compressor offers an excellent solution of economical operation.

A notable comparison of the economy of the duplex compressor with the straight line compressor was recently reported from a Penn-

sylvania anthracite mine, where coal at $0.40 per ton was burned under the mine boilers. A large double-cross-compound Corliss steam compressor replaced 2 Meyer valve tandem-compound straight lines of equivalent combined capacity. The first few months of operation showed savings in fuel, water and labor realized by the new machine indicating a yearly saving of a little less than $9,500, with the Corliss compressor running noncondensing. A condenser has since been installed so that still greater savings have been realized, leading to a duplication of the equipment.

In the case just cited, comparison is between a splendid compound Corliss steam 2 stage air unit, and 2 simple-Meyer-steam, 2-stage-air straight line compressors, but another example —outside the mining field, but still typical of what might be realized in mining work—will furnish further evidence.

One of the contractors on the Catskill Aqueduct construction, New York, operated 2 different types of compressor plants on 2 sections of his work. One consisted of 4 double-tandem-compound Corliss-steam air compressors. The other comprised 2 double-cross-compound Corliss-steam air compressors, each with a capacity almost identical with that of each straight line unit in the other plant. Both plants were operated under identical steam and air pressures and vacuum, and under almost identical load conditions.

At the end of 16 months, the contractor needed more air; and to determine whether to buy straight line or duplex units for his addition, he went back over the fuel costs of his 2 plants for the previous 16 months. He found that his fuel cost for the double-tandem-compound compressor plant had been $58,000 or $5.92 per cu. ft. of free air for 16 months. While the coal cost at the double-cross-compound compressor plant had been $15,000 or $2.90 per cu. ft. of free air for 16 months. The figures showed that, had he been using the duplex compounds throughout, he would have saved $29,596 in cost of coal alone during the 16-month period. And the added saving in labor, oil, supplies and depreciation would probably have brought the total up to $40,000, or a rate of $30,000 saved a year. The contractor's order for added equipment was for duplex compressors.

The same ratio of saving could be realized in mining service, whether in coal mining where fuel is cheap, or in metal mining where coal is dear.

POWER DRIVEN COMPRESSORS

While the foregoing has referred only to steam-driven compressor units, modern mining practice is tending toward a standardization on the duplex power driven type also, for mining service, for much the same reasons that have given the steam-driven duplex the preference. The power-driven mine compressor is almost invariably electric driven. The straight line type cannot be direct-connected; the duplex, on the contrary, offers ideal conditions for direct shaft drive, and the writer believes that it is only a question of time when this type, in comparatively large capacities, will predominate on purely economical grounds, as it minimizes losses between motor and compressor cylinders.

With large-capacity, constant-speed, power-driven units, the only efficient means of regulation is in rendering ineffective, in delivery of air, part of the piston displacement. To do this on a compound straight line causes unbalanced conditions prejudicial to good service and wearing power. But the duplex permits this to be done without any sacrifice of the pressure equilibrium of the machine, and regulation under a variable load factor is smooth and easy on the unit.

AIR TRANSMISSION SYSTEM.

Now, having taken due care to produce compressed air at lowest cost, shall the seeking after economy in the mine air plant end here? With the drills, hoists, pumps and other air operated devices of the mine, this paper has not to do. But the delivery of compressed air from compressor to machine very properly is a function of the compressed air plant. Needless to expatiate upon the folly of making air cheap, and then sacrificing the gain through a leaky, inefficient insufficient distribution system.

First, the receivers—they are the flywheels of the air power system, the buffers interposed between the sudden, irregular drafts of the air machines and the steady pull of the compressor. Let the receiver capacity be ample; here, if anywhere, extravagance is a virtue. Let the receivers be in the cool out-of-doors, rather than in the hot engine-room. And remember that receiver drain cocks were provided to be used.

If continued trouble be experienced from freezing up at the exhaust of the air machines,

put in an after-cooler to dry the air. For the water vapor which has been freezing at the machines will then be condensed, precipitated, and can be removed from the air before it enters the pipe lines. More than this, an after-cooler will send only cool air into the pipe lines, so that expansive and contractive movements due to carrying hot air and later cooling will not give rise to a leaky distribution system. And air dried in an aftercooler will prevent accumulation of water in the air lines, with "water hammer" and loss of transmission economy.

For the pipe lines, figure the diameter by the most generous formula for capacity and pressure—and then use pipe a size or two larger than is indicated. And remember that the maximum capacity must be provided for, whatever the average load factor that may be anticipated. For it is at moments of maximum demand that the air lines will be put to the severest test; and what shall it profit a mine manager if he gain the highest economy at his compressor and then lose most or all of his saving by insufficient air pressure at his drills? Pressure is the vital thing in a rock drill or stoper; and while "air cannot be lost" in a tight pipe line, because loss of pressure means increase of volume, it is the pounds-per-square-inch on the drill piston which drives the drill hole in the least time, which means the least labor charge.

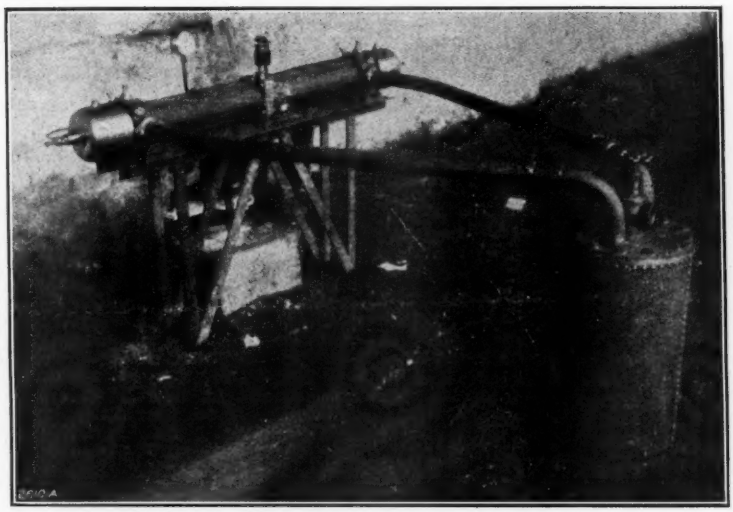
So let the pipe lines be designed to deliver both volume and pressue—volume determining the number of machines that can be used, pressure determining the amount of work each machine will do. Abhor the short-turn elbow; cultivate the wide-bend habit. Air in motion finds as much difficulty in turning a right-angled corner as a running man or a mule. Let the pipes and fittings underground be protected so far as possible from acid, water, rerailed cars, and falls of rock. Let drain cocks be placed, and used, in the low places. Keep a good big air pipe always right up to the drill manifold; let the air hose be the last and smallest element in your distribution system.

And keep all joints tight. Test the pipe system at night, or on a Sunday, when all the machines are known to be stopped, by running the compressor until normal pressure shows on the receiver gage. Then see how many turns of the compressor are needed to maintain that pressure. This will show the "leakage load" and represent the waste of power going on every minute that pressure is on the system. One manager, who was cursing the voracious air consumption of his drills, was induced to make this test, and found that he had to run his machine steadily at 25 per cent. normal speed, to keep up pressure on an absolutely unloaded pipe system. He decided it was cheaper to stop the leaks in his pipe lines than to install more compressor capacity and more drills. There are doubtless many others waiting to make this same discovery.

AN INTERNAL COMBUSTION COMPRESSOR

The illustrations which we here reproduce from Engineering, London, show an internal combustion air compressor with a free piston which has been constructed and actually operated by Signor Guiseppe Matricurdi, Lago Maggiore, Italy. Fig. 1 is from a photo of the compressor and connections. Fig. 2 shows the construction and operation diagrammatically, and Fig. 3 is a complete duplex indicator diagram.

The cycle of operations in such a compressor is as follows:—A heavy piston is propelled from one end of a cylinder to another by the explosion of a charge of gas behind it. During its motion it expels the air in front of it through a port, and thence through a non-return valve into a reservoir. The piston near the end of its travel over-runs the port, and compresses into the end of the cylinder a fresh charge, which is exploded in its turn, shooting back the piston to the other end. In its passage the piston compresses and discharges into a reservoir the air in front of it, as before. The piston is thus shot to and fro between the two ends of the cylinders, drawing in air on one side, and compressing and discharging it on the other. Each end of the cylinder is closed by a large valve, through which the air to be compressed enters the cylinder. A cap arranged over each cylinder end, as indicated, causes all this air to pass between studs cast on the outside of the cylinder, which is thereby cooled. The stem of each of these air-admission valves is hollow, and terminates in an enlarged end as shown. Just beneath this enlargement a number of fine holes are drilled through the wall of the valve stem, which, when the main valve is closed, are in communication with the fuel-pipe *a*. If,



FIG

however, the main valve opens, these small orifices are masked, so that no fuel can enter from the fuel-pipe during the process of drawing air into the cylinder. The supplementary openings shown at *b b* may be used to supply a charge of compressed air in starting up.

The working of the device is as follows:— Supposing the piston at the left-hand end of the cylinder, with a charge between it and its cover. This charge is fired by the rise of temperature due to the previous compression, and expands along the line A B of the indicator diagram, Fig. 3. When the piston reaches the point corresponding to B, it uncovers the port in cylinder wall, and some of the gases behind it, being at a higher pressure than those in the reservoir, pass through this port into the latter, the pressure of which is represented by the point C. As the piston moves forward the pressure falls down below that of the atmosphere, as represented by the point D, and a suction stroke is made, which terminates at E. The piston then begins its return stroke. The inlet valve being closed, and the pressure inside the cylinder being less than that of the reservoir, a charge of petrol or oil is sprayed through the fuel-valve until the return of the piston has compressed the entrapped air to F. The pressure then remains constant and air is discharged into the cylinder until the piston masks the discharge port at a point corresponding to G on the diagram. Compression then commences and continues along the line G H until the temperature rises

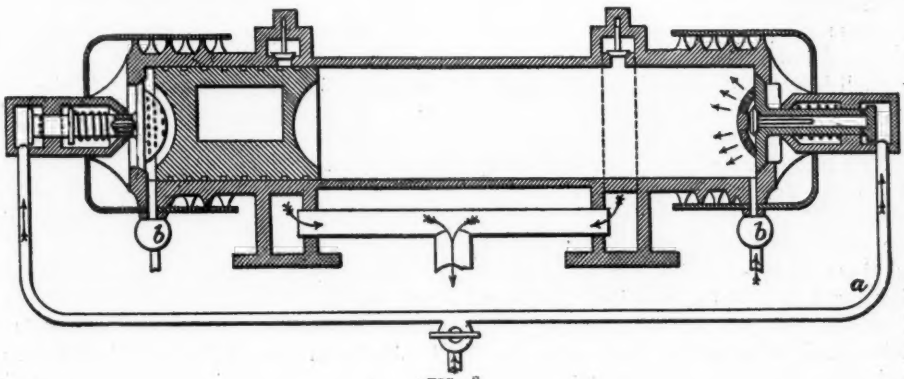


FIG. 2.

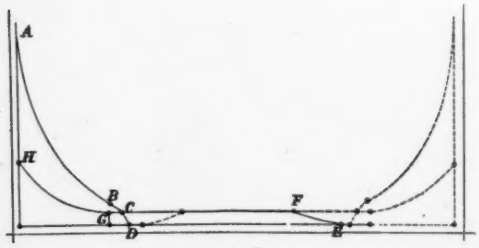


FIG. 3.

sufficiently to ignite the charge, when a return stroke is made. The cycle of events and the indicator diagram is exactly the same for the right-hand side of the cylinder as for the left. The fuel charge is, it will be seen, not admitted until after the air-inlet valve has closed. It thus remains near the head of the cylinder, and is not wasted through the discharge-pipe to the reservoir. The whole of the products of combustion pass into the latter, raising the temperature of the mixture there and increasing its available energy.

A PNEUMATIC STREET CLEANING MACHINE

The illustrations here reproduced from the pages of Engineering & Contracting, show the Furnas pneumatic street cleaning machine as described by Mr. C. A. Tripp, Indianapolis, in a paper before the Indiana Engineering Society.

The machine is an automobile adaptation, the propelling motor being used also for actuating the sweeping device. The sweeping hood is shown resting on the street surface. This is preceded by a set of coarse brushes, or rather scratchers, which loosen any dirt that may be stuck to the street surface. The dirt is taken up and deposited in the dirt box, the bottom of which consists of two doors which can be dropped for depositing the load. The small boiler shown furnishes a supply of steam which dampens the dirt, aiding in its separation from the air, and also forms it into a dustless mat or cake in the box, so that no dust is made when dumping or when loading into wagons.

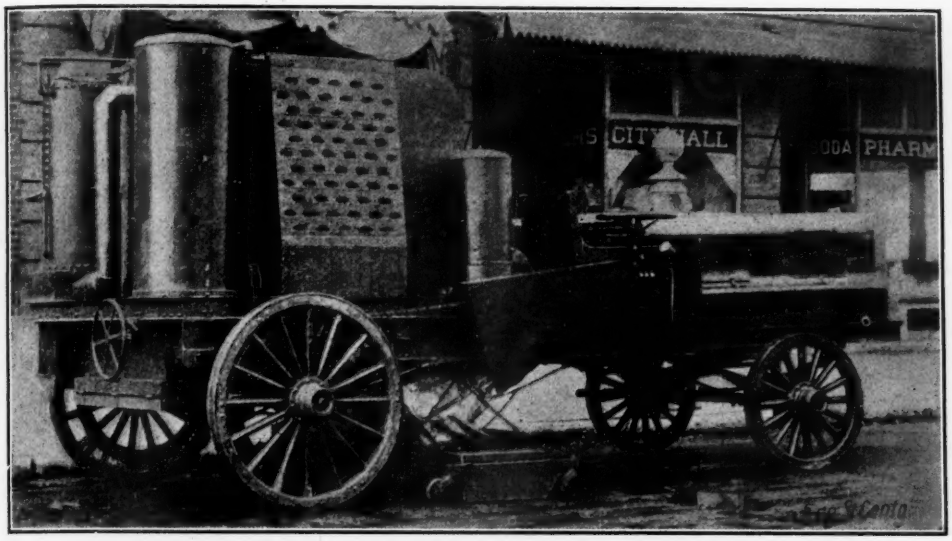
The sectional view, Fig. 2, shows the air circulating system, which is the interesting and all important part of the machine. The general plan is that the air used for sweeping is recirculated, being used over and over again, with the exception of a small amount which is taken out to provide for leakage, as will be explained later.

The sweeping hood consists of an inner and an outer portion. The outer portion is inclosed by short curtains or lines, made of canvas, to which small plates of iron are riveted. These plates serve to weight down the canvas and also to take the wear due to dragging on the street. They are sufficiently light, however, to pass over the dirt and not act as a brush or scraper. The inner portion is separated from the outer portion on the front side by a similar line, but on the rear side by a metal strip which runs at a distance of about ½ in. from the street surface. This is the real sweeping point. The air comes down in the outer portion at a comparatively low velocity and at substantially atmospheric pressure. The inner portion is under the full suction of the fan. The air rushing through this narrow opening at high velocity and in a direction practically parallel with the street picks up the dirt, which is then carried up through the opening in the center of the inner portion.

As shown this opening is connected directly to the fan suction. From the fan the air and dirt enter the centrifugal separator, which is directly above the dirt box. Here a small amount of steam is blown in, as previously described. After the air has deposited the dirt picked up from the street it leaves by the center tube and returns directly to the outer portion of the hod. Within the center tube by which the air leaves the separator is a small pipe, which is open at the lower end. A small amount of the air leaves by this pipe, which leads to the ash pit of the boiler. The amount of air taken out through this pipe is equal to the inward leakage to the outer portion of the hood.

The pressure in the separator, and hence the amount of air leaving by the small pipe, is controlled by the damper shown in the passage between the separator and the hood. Indirectly this determines the pressure in the outer portions of the hood, which is maintained at or slightly below that of the atmosphere, so that any leakage is inward, thus preventing dust.

The small steam boiler serves a double purpose. Steam added to the dirt and air as it enters the separator, increases the weight of the dust particles and thus aids in the separation. It also dampens the mass of dirt so that



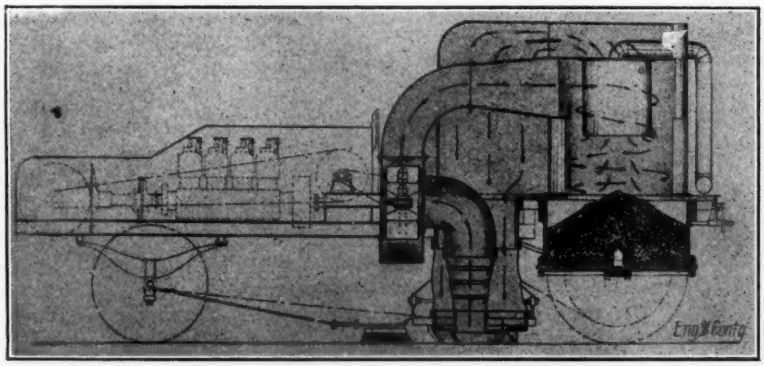
PNEUMATIC STREET CLEANING MACHINE.

dust is prevented when dumping. The air returning to the hood, and therefore the air leaving the separator by the small off-take pipe, carries a fine dust which it is very difficult to separate. The fire in the boiler serves as an effective filter for removing this from the small volume of air which must be discharged, while the air acts to produce draft for the fire.

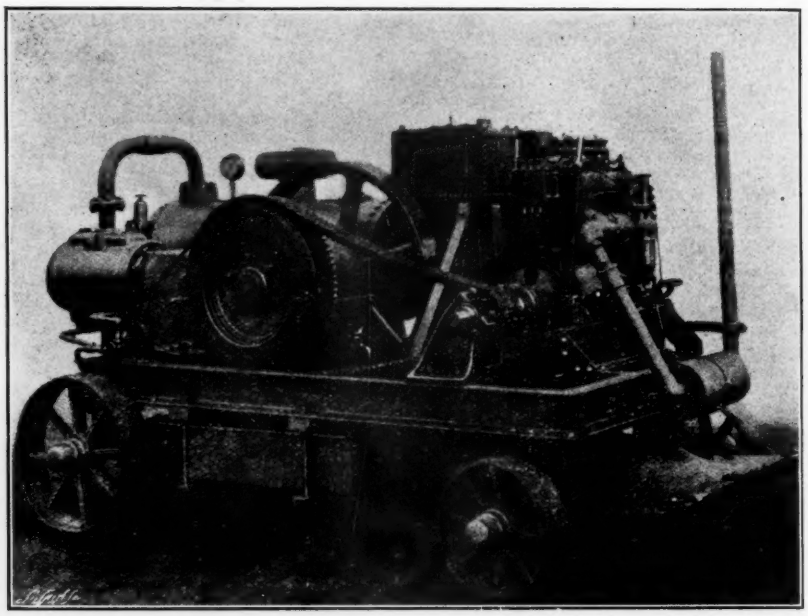
The power equipment consists of a 6x6 4-cylinder engine, located at the forward end of the machine. The sweeping fan is driven from the rear end of the engine shaft through a cone clutch and spur gears running in oil. The power for propulsion is taken from the front end of the shaft and transmitted through a friction drive and differential jack shaft to the rear wheels. The maximum speed of travel is 5½ miles per hour, which may be reduced by the friction transmission, as required by the condition of the street being swept.

The machine is operated by two men. The driver controls the steering, and propulsion and fan speeds. The operator controls the pressures in the air system, raises and lowers the hood as required by means of the two levers shown, fires the boiler and dumps the dirt.

Air nitrates, produced electrically in Norway, according to Consul General Bordewich, are sold for export at an average of $39 per ton at the works, exclusive of packing.



SECTION OF STREET CLEANING MACHINE.



A PORTABLE AIR COMPRESSING PLANT

The half tone shows an interesting portable air compressor and drive in use in England for driving pneumatic tools and other work of a temporary character. It is self-contained and complete comprising essentially an Ingersoll-Rand compressor and a Parsons kerosene engine with their appurtenances mounted on a truck with wide tread wrought iron wheels, the over-all dimensions being 7 ft. 10 in. by 4 ft. 1 in.

The compressor cylinder is 8 by 8 in., and at 210 revolutions delivers 80 cu. ft, of free air per min. at 80 lbs., gage, into a horizontal receiver 60 by 21 in. The compressor has an automatic intake controller and flood lubrication. For cooling the cylinder there is a water tank under the truck and a small pump for circulation. Power is transmitted from the engine to the compressor by a Westinghouse Morse rocker chain and a special spring tension wheel.

The motor is a three cylinder enclosed engine, the cylinders being 4½ in. base and 6 in. stroke, developing 21 horse power. The engine may be started either by injecting a small quantity of gasolene or by employing a blow-lamp. The charge is fired by a magneto having a patented timing drive whereby the requisite amount of advance or retardation of the point of ignition is secured. The speed is controlled either by a governor or by hand. An all-metal clutch is provided between the engine and the chain pinion, allowing the engine to be started without the compressor load.

Water circulation is provided for cooling the motor, a Parsons pump being fitted to the engine for the purpose. The pump draws its supply from the bottom of the radiator and after passing the water around the cylinders delivers it to the top of the radiator which has a large fan in connection with it. A silencer is used discharging the exhaust vertically. The engine is started by a detachable crank on the end of the shaft.

Swiss railroad tunnels are reported to number 415 and have a total length of 103 miles, by the "Revue Générale des Chemins de Fer." The principal ones and their lengths in miles are: Simplon, 13.00; St. Gothard, 9.50; Lötschberg, 9.25; Mount Cenis, 8.50; Arlberg, 6.50; Ricken, 5.50; Montier Granges, 5.50; Täuern, 5.50; Hauenstein, 5.00; Mont d'Or, 4.00; Albula, 3.75; Weissenstein, 2.50.

COMPRESSED AIR IN BOILER SHOPS*

A boiler shop without air tools is almost unthinkable in these days. The purpose of the present paper is to run over, briefly, the production, transmission and use of air and the general operation of air tools.

The character and quantity of shop output must determine the equipment. Such questions as these arise at the beginning: Is the output standardized, and is the work mainly duplication in small or larger quantities? Is it special, each case almost individual, or does it fall in the much larger class of jobbing, part repair and part manufacturing? A discussion of the general subject will take its shape according to whether it is to cover an existing plant or the planning of a new installation.

THE COMPRESSOR.

Conditions change and the demands for air grow, so that an equipment which in the beginning may be quite adequate and proper in time becomes inefficient and insufficient. The wide range of uses to which compressed air lends itself is not at first fully appreciated, and only the most experienced can approximately estimate the demands which later will have to be met.

General experience shows that for best all-round work the proper pressure at the point of application is from 90 to 100 lb., and in some cases even slightly higher; however, 100 lb. at the tool will meet every requirement of 99 cases out of 100.

To give 90 to 100 lb. at the tool will call for a terminal or receiver pressure of from 100 to 110 lb., depending on the piping or transmission system, to be discussed later. We now have the first production factor—pressure. Next comes the question of volume of air required, and this in turn necessitates a careful study of present and future requirements: What types of tool; the number of each to be operated; the probable number operated at the same time; the average time of operation of each; what special appliances will be installed; is air to be reheated, and what provision is to be made for growth?

Fairly accurate tables are obtainable giving the air requirements for all standard tools and machines, and data are available from which the total volume of air needed can be readily worked out, or the manufacturer of compressor and tools will be very glad to assist in determining this second factor.

POWER AVAILABLE.

If steam is at hand a steam-driven compressor of simple, duplex or compound type, depending on the steam pressure and volume of air, generally recommends itself.

With low steam pressure from 75 to 100 lb. and a required volume not exceeding 800 ft., a single air cylinder finds frequent use. This type is not the most economical from the steam standpoint, but is compact, simple in construction and has many desirable features. Above 800 ft., and with the same low steam pressures, the duplex type with the advantage of four power impulses for each revolution is frequently employed. Either duplex or two-stage air cylinders are used with this type. When the steam pressure is above 100 lb., compound cylinders should generally be employed, and especially if the steam pressure is much above 100 lb.

For the larger sizes, from 1000 cu. ft. up, compound steam cylinders are almost essential and also two-stage air cylinders. Larger units, of 2000 ft. and upward, should be of the Corliss type, their greater first cost being soon offset by the considerable saving effected by their low steam consumption.

It is also well, when the volume of air to be supplied is large, to install two units, each having a capacity equal to light working demands or both together having a combined capacity equal to maximum demand and also some reserve for growth.

BELT OR ELECTRIC DRIVE.

In many shops where shafting is running near the location selected for the compressor, and surplus power is available, a belt-driven machine forms the most satisfactory type. For belt-driven, except in the smaller sizes, the duplex—that is, two cylinders side by side, driven from one shaft having a pulley at the center—is the most desirable form, as it gives four compressions per revolution, thus producing a more even belt load. In every instance where electricity is available a belt com-

*Condensed from a paper by Thomas Aldcorn, before the American Boiler Manufacturers' Association, New Orleans, March, 1912.

pressor can be driven from a suitable motor. This arrangement is advantageous, in that it permits starting or stopping at will, without the intervention of idle pulleys, clutches or other power-absorbing devices.

Latterly motor-driven compressors are in considerable demand, either geared or, in the case of larger units, with motor mounted directly on the compressor shaft. For the smaller sizes an automatic starting controller and pressure regulator can be furnished if desired, and this will maintain practically a constant pressure, shutting down the motor when the desired limit is reached, or starting up where the pressure falls, due to an increased demand for air. Still another method of driving in larger units is to mount the motor armature or rotor directly on the compressor shaft, an arrangement somewhat like a direct-driven generator outfit. The power is applied directly to the shaft, and all belts, gears and other parts are unnecessary.

INLET CONDITIONS.

In piping up the compressor it is well, if possible, to take the inlet air from the shady side of the building or from outside the engine room, where cool air can be obtained, as each 5 deg. reduction in initial temperature will effect a saving of 1 per cent. in the operation of the compressor, or intake air 25 deg. colder will increase the capacity of the compressor 5 per cent. It is also well to make the inlet of good size and as short and direct as possible, to reduce inlet friction to a minimum.

Often, and always if in a dusy or sooty location, it is advisable to put a strainer on the exposed end of the inlet pipe or box. Such a strainer can be readily made by covering one side of a substantial box with wire netting and putting outside of this one or two layers of muslin, through which the air must be drawn. While a strainer is not essential under ordinary conditions, in many cases it is, and in nearly all cases strained air will help avoid lubrication troubles and add to the life of valves, piston and glands.

THE AFTERCOOLER.

The compressed air leaves the compressor at a fairly high temperature, averaging about 350 deg. As the amount of invisible moisture which can be held in air depends on its temperature, it is evident that all the moisture taken into the compressor is also discharged therefrom, to condense in the receiver or air mains later on. That this needs consideration is evident when it is recalled that a 500 cu. ft. compressor will draw in through the intake pipe $500 \times 60 \times 10 = 300{,}000$ cu. ft. of air per day of 10 hours, and on a damp or rainy day this may contain as much as a barrel of water for the day, although the average would be less. For this reason, especially in the larger installations, an efficient aftercooler is most desirable, and it is actually essential if the transmission lines are long or exposed to the outdoors.

The aftercooler is a device arranged to take advantage of the principle mentioned; that is, air will carry a varying amount of moisture, depending on its temperature, or at a given temperature air will hold only a certain amount of moisture, beyond which it becomes saturated and the excess moisture will be precipitated as dew or rain. Hence, if we can reduce the temperature of the air below that at which it will enter the transmission mains, moisture troubles will be very largely eliminated.

Of course, it must be remembered that when the air is actually used or expanded in the exhaust of the pump, engine, drill or other air-driven device the rapid expansion causes a temperature reduction considerably below what can be obtained in the usual water-cooled after-cooler, and there may be some precipitation from the compressed air at the point of application. Usually, however, the moisture noticed around air tools is on the outside and is really the accumulation from the surrounding air, like the moisture on the outside of a glass of ice water.

THE RECEIVER.

From the compressor and aftercooler the air passes to the receiver, which performs a twofold function: First, as an equalizer of the pressure, to receive the rapid pulsations of the compressor's discharge, and, like a spring, or the gas bag on a gas engine, equalize or smooth out the pulsations, thus insuring a steady flow of air to the transmission lines. Second, to contain a stored supply of compressed air, which helps the compressor over any sudden momentary increased demand for air.

There is an erroneous idea current with re-

(*Continued on page* 6436.)

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THE ELECTRIFICATION OF THE QUARRY

Perhaps few lines of industry have been more improved in means and methods employed and in results accomplished than has been the cutting of stone from its native bed. This is one of the primitive, as it seems also to be one of the most enduring of man's occupations, coming next perhaps to the hewing of wood and the drawing of water. These two latter, the getting of fuel to keep warm and to cook by and the conveying of water to drink and bathe in, cited originally as the most menial and enslaving of occupations, have been dignified into the life work of the great engineers, and the getting of building and monumental stone is now similarly elevated.

The first cutting of stone could scarcely have been called cutting at all. It was a splitting or tearing away of fragments whose shape and dimensions were largely determined by chance, much as a hungry man might tear away his mouthfuls of bread from a stale and crusty loaf. What we take from the loaf now is carved in regular slices and the loaf itself is respected and left in perfect condition for the next carving, so that it might gladden the heart of a careful housewife to look at it. In the cutting of the stone now there is no wasting of the material, and the pieces got out can be shaped and finished to predetermined dimensions with a minimum of labor.

The stone channeler has been the most active and effective agency in the development of the modern quarry along the lines of precise, systematic and profitable operation, and the sight of a great plant where the channeler dominates cannot but be gratifying to anyone who has any appreciation of the difficulties and the exactions of this line of work.

The stone channeler, while unique in its line of work from the first, has had its long period of development and of approach to the perfection of design and action which is never quite attained. It has grown larger and heavier and more elaborate, but all the while it has been more especially acquiring the knack of doing more and better in its special line.

The channeler has been quite generally steam driven, each having its own boiler as an integral part of it, and being thus self contained and independent of everything except an unfailing supply of fuel and water. The firing of the boiler and the maintenance of the

supplies for it have of course entailed much extra cost of operation, a feature most desirable to avoid, and so other channelers have been operated very satisfactorily with compressed air, but here also were a compressor and pipe lines to be provided and the accompanying cost of them.

It must have been a most welcome consummation when the electric air drive and the track channeler got together, for their mutual benefit and for the comfort and profit of all concerned. These are so evidently adapted to each other that it might be said they could not long have been kept apart in any case. The channeler churns along in a livelier way than ever before; does more work and requires less than half the power to do it, and there are no offsetting disadvantages to be compromised with. The electric motor and pulsator apparatus ride upon the machine in the most comfortable way, taking up less room than the displaced boiler.

Most important of all, the coming of the electric air drill, and especially of the electric air channeler, makes it possible to use one system of power transmission for the entire plant. At the present writing the electric equipment is a necessity for lighting, and for power purposes it approaches the ideal. Quarries are quite apt to be located within reach of water powers which can be utilized to drive generators, thus providing the cheapest power known. It is a curious thing that a special compressed air invention, which after all the electric air drive distinctly is, should so help to promote and extend the reach of the electric current.

BARGE CANAL AND PANAMA CANAL

It would seem that the N. Y. State Barge canal, as an engineering work of great magnitude involving many diverse and difficult problems, has not received adequate appreciation. The Barge Canal Bulletin cites as below a number of particulars in which the work may be compared with that of the Panama canal.

The Panama canal is 50 miles in length; the Barge canal, including navigable lakes, 350 miles in length. The estimated cost of the Panama canal is $375,000,000. The estimated cost of the Barge canal is $108,000,000, but these estimates of cost are not indicative of the amount of work being done. On account of the large amount of excavation necessary at the Culebra cut in the Panama canal, the total excavation is much greater than for the Barge canal, being 175,000,000 cubic yards as compared with 110,000,000 cubic yards. Concrete to the amount of 5,000,000 cubic yards will be used in the Panama canal construction, and approximately 3,000,000 cubic yards on Barge canal construction. At Panama the concrete is placed chiefly in the six pairs of locks, while in the Barge canal construction, the number of structures greatly exceeds the small number at Panama. There will be 57 standard locks on the Barge canal and several smaller ones. Thirty dams will be built and several remodeled. The bridges to be constructed will number nearly 200, making the total number of structures to be erected in the Barge canal improvement between 350 and 400. Comparisons are not altogether possible where conditions are variable, but taking into consideration the length of the canal, the number of structures, the alignment through a well developed country and the necessity for maintaining navigation, together with the difficulties encountered through cities in the construction of the Barge canal, the people of the state have some reason for satisfaction in their unaided accomplishment in canal construction.

VENTILATION NEGLECTED IN SINKING SHAFTS

At Thorus Colliery, Yorkshire, England, where shaft sinking operations were being carried on an accident occurred enforcing an important lesson. The shaft was 22 ft. in diameter and had reached a depth of only 120 ft. A round of 15 shots in the bottom of the pit had been fired by an electric battery, each shot containing 1¼ lb. of gelignite. Immediately after the firing of the shot a foreman and laborers descended the pit in a hoisting bucket ("bowk"). On reaching the bottom of the shaft, about five or six minutes after the shot had been fired, the men began to cough, and several of them became very weak and ill.

A second gang of laborers descended and reached the bottom of the shaft about 15 min. after the first gang, and one or two of them also were affected by the fumes. During the shift several of the first gang became so ill that they had to cling to the rings of the shaft; but the significance of the symptoms men-

tioned was not realized by either the men themselves or those in charge of the work. The men temporarily recovered, with one exception, this man going to the surface an hour before the completion of the shift; the rest worked about three hours after the firing of the charge mentioned above. Then they went home, but during the night several of them became seriously ill, and one died about the middle of the next day (Mar. 17).

All the men who went down in the first bucket, and one at least of those in the second bucket, developed similar symptoms. No mechanical means had been taken to produce a ventilating current in the shaft, and the heat of the steam pipes used therein caused a current of air, which was depended upon to ventilate the workings. The shaft was wet; the amount of water being made being about 120,000 gal. per hour.

The symptoms show that those of the men who were affected by the poisonous fumes of the shot were suffering from the effect of carbon monoxide, and nitrous oxide poisoning. Prominent among these symptoms was a confusion of thought and expression, even when the persons affected thought themselves quite well (pointing to the presence of carbon monoxide), and violent coughing (pointing to nitrous-oxide poisoning). The inferences which may be drawn from this case are that carbon monoxide was responsible for the more immediate symptoms, and the nitrous fumes for the bronchitis.

TUNNEL BUILDING AND SCENERY PRESERVATION

The following extract from a tunnel contract it is needless to say was not written in the United States. It refers to the Arthur Pass tunnel, under construction for the New Zealand Government Railways:

"The works are situated in a national scenic reserve. The contractor shall carry out all his works in such a way as to cause no permanent disfigurements. Workmen or others connected with the works convicted of setting forest or bush or other vegetation on fire will be liable to immediate dismissal and to prosecution. Beyond the formation of the approach cutting at the Bealey end of the tunnel no works of any kind, except such as may form part of this contract, and no cutting of timber will be permitted on the hillsides on the left bank of the Bealey within 40 ch. of the tunnel mouth, both up and down stream. At the Otira end of the tunnel, no timber will be allowed to be cut from the forest for construction purposes, and only firewood from fallen or dead trees will be allowed to be used by the contractors or workmen as permitted by the Resident Engineer. In the Bealey valley, timber may be allowed to be cut in such restricted quantities and in such localities as shall be allowed by the Resident Engineer."

BREATHING

The amount of air breathed in at one normal inhalation of an average male adult is 500 cubic centimeters, or 30.5 cubic inches; but when taking vigorous exercise, seven times as much. The total area of the lung surfaces is about 30 square meters or 323 square feet; that of the body, however, only 2 square meters or 21.53 square feet.

An adult breathes ordinarily in a minute, about 18 times; when doing ordinary physical work, 25 times; when taking vigorous exercise, 60. In case of inflammation of the lungs the respiration takes place at the rate of about 40 breaths a minute. In the nasal passages the air is warmed more rapidly and thoroughly than when it passes into the lungs through the mouth. Air at a temperature of 6 deg. Cent.=42.8 deg. Fah. is raised to 32 deg. Cent.=89.6 deg. Fah. during the short time of an inhalation through the nose. The reason of the more thorough warming by nasal breathing is that the total surface of the nasal passages in the average adult is 100 square centimeters or 15.5 square inches; those of the mouth having an area of only 70 square centimeters or 10.85 square inches.

In Sydney, Australia, recently two workmen were accidentally electrocuted under quite different conditions. One man was a rock-driller working on the sewer outfall works at Long Bay, and his death was caused by the current short-circuiting with a rock-drill which he was handling. The second case was that of a fireman employed at Saxton and Binns' timber yards at Pyrmont. He was carrying a small flexible extension electric hand lamp, when, owing to a short circuit occurring, a current of 2400 volts passed through his body, death being instantaneous.

(*Continued from page* 6432.)

gard to the storage of air, for, without the use of an excessively large receiver it is not possible to store more than a few seconds' or a minute's supply. A receiver 48 in. in diameter and 12 ft. long contains about 153 cu. ft.; when filled with air at 100 lb. pressure it will hold about 1200 cu. ft. of free air. If the compressors supplying were shut down the flow through a 1½-in. main would in a few seconds drop the pressure from 100 lb. to a pressure too low for working purposes. It is therefore evident that, except under peculiar conditions, the storage feature should be ignored and a compressor installed of sufficient capacity to easily take care of immediate and reasonable future requirements.

Frequently it is a good plan to install additional receivers at junction points or elsewhere in the transmission system, to equalize the pressure and to take care of any sudden or excessive local demand. These auxiliary receivers also act as separators to remove from the air additional grit and moisture.

THE TRANSMISSION.

The transmission system of pipes conveying the air from the compressor to the various points of usage should receive most careful attention, both in location and in putting up. Lines should be made of ample proportion and figured with due regard to equivalent areas. They should be run as direct as possible, with few turns or angles, and it will pay in the end if bends or long turn fittings are used. Branches and outlets should be near enough to permit of sufficient tools being operated without the use of long hose lines, usually so that a 50-ft. hose will over-reach another 50ft. hose. Each branch should have a tee and two outlets closed with good, solid globe or gate valves.

The practice of using nothing less than 1 in. pipe for branches is to be recommended. Full-weight pipes, substantial fittings, first-grade valves and care in supporting mains, drops and branches are all essential, for it must be remembered that with air at 100 lb. pressure a 1-16-in. hole will leak the equivalent of a horsepower.

All piping should be carefully inspected, rapped to break loose inside scale, and then blown out. All joints should be made up with lead and screwed up tight, and every precaution taken to make the work permanently airtight. At suitable points drip tanks or separators should be inserted in the mains, these being provided with drip cocks. Drip cocks should also be placed at all low points.

Outlets should all be provided with an approved form of universal quick-acting and locking hose coupling, and the same form should be used through and on all hose for interchangeability.

Only the best grades of hose should be used, wire wound for the longer or leader hose, and a short length of plain tubing for connecting with the leader. All hose should be cared for. It is expensive and deteriorates rapidly, and it has been shown that many troubles charged against the tool have been due entirely to the use of poor grades of hose. The hose should be regarded as part of the tool equipment, and each man to whom hose is issued should be held responsible for its return in good condition.

In every case when getting ready, the valve at the outlet should be opened an instant before connecting the hose. The hose should then be blown out, and then the hose connected to the tool.

PNEUMATIC TOOLS.

First in importance should be mentioned the chipping and riveting hammers. The chipping, calking and bending hammers in six or eight different sizes for every character and weight of work, from the thinnest to the heaviest plates, range in weight from 6 to 16 lb., with strokes from 1 to 5 in., and these striking at from 840 to 3200 per min., with air at 100 lb. pressure, acting on a 1 1-16-in diameter piston. It would seem that no argument is necessary to prove the advantage of these wonderful labor-saving tools over the old hand methods in the hands of even ordinary unskilled help.

Pneumatic chipping is unquestionably many times more powerful and efficient than hand chipping. Further, on account of there being no necessity to "swing a hammer," it is possible to work in out-of-the-way places and corners where hand chipping could only be done with the greatest difficulty. The varying sizes of these tools makes it possible to select a hammer to meet any peculiar set of conditions, and the spring throttle, which is always under the control of the operator, permits an

instantaneous adjustment of the blow, from a very light tap to the full power of the hammer, thus enabling intricate chipping to be done quickly. Further, the chipping can be carried on very much closer to the finished size than can possibly be done by hand.

When it is considered that an ordinary operator can take a ⅜-in. chip off a ½-in. plate at the rate of 8 in. per min., and this is compared with the time and work which would be required to cut the same chip by hand, some slight idea of the advantage of pneumatic chipping can be gained. It is a conservative statement to say that one man with a pneuamtic chipping hammer can do from three to five times as much as he could do by hand.

For calking, the pneumatic hammer is ideal; for, by selecting the proper weight of hammer or throttling the air pressure so as to limit the force of the blow, the metal can be condensed and calked with an evenness impossible with hand methods, and the depth of the compacting of the metal can be regulated to suit conditions. In addition to the plate chipping and calking, in most boiler shops there are usually iron or steel castings, all sorts of brackets and supports, stack bases and other parts in and around the boiler or boiler settings, all of which need a certain amount of dressing.

FEATURES OF THE PNEUMATIC RIVETING HAMMER.

The penumatic riveting hammer of the long-stroke type, weighing from 14 to 21 lb., depending on the class of work for which it is intended, and having from 840 to 1080 blows per min., is a marvelous device, and even in the hands of an inefficient operator does so much more work and does it so much better than could be possibly done by hand that it is inconceivable that any one would tolerate hand riveting of any sort.

It is not safe to heat a steel rivet beyond a certain point if its fibrous texture is to be retained and the full strength of the rivet made available. If the rivet is driven by hand it will be seen that, no matter how rapidly the riveters strike, they cannot possibly upset and heat the rivet as quickly as it can be done by a machine which strikes a more powerful blow, probably 10 to 20 times faster than any riveter can possibly strike. On this account the rivet fills the hole and is headed before it is cooled to any great extent, and as it cools and is followed up by the riveter, the plates are clamped together tighter than is the case with a hand-driven rivet. Besides, there is less likelihood of the rivet running over and heading up off the center.

It is impossible to imagine any form of working machine simpler in construction than a riveting hammer, consisting as it does of the barrel, valve box and valve, handle and trigger, and while we sometimes hear complaint as to the cost of repairs, such cost is trifling compared with the results obtained. In fact, we do not believe it an exaggeration to say that any good shop has its capacity doubled or tripled by the introduction of pneumatic chippers, riveters and drills.

OTHER DEVICES FOR WORKING ON RIVETS.

Along with pneumatic hammers come, of course, pneumatic holders-on for backing up the rivets; jam riveters for working in restricted places or in flues and other positions where the ordinary riveter cannot be operated; rippers for cutting up tanks, boilers and other plate work; rivet busters for flogging off the heads of rivets and stay bolts, for purposes of repair or absolute dismantling of boilers and tanks, and other special devices of kindred sort, many of which are specially made, having been developed in some particular shop.

Pneumatic compression riveters, either portable or stationary, and yoke riveters of varying design are largely used where the character of work demands this type. When properly mounted so as to be flexible they constitute a very important addition to any boiler shop equipment. In principle the compression riveter is much the same as the ordinary hydraulic riveter, except that the riveting plunger is advanced by means of a toggle or an arrangement of levers in turn moved by a piston moving in a compressed air cylinder.

PNEUMATIC DRILLS.

Pneumatic drills—that is rotating drills for metal drilling—are made in various sizes, ranging from the smallest, generally for wood boring, up to the powerful compound gear type having a capacity to drill up to 3 or 4 in. in metal and weighing up to 118 lb. In principle they consist of a multiple cylinder air-actuated engine, driving a crankshaft which is geared to the drill spindle or socket which takes the

drill. On the smaller sizes the spindle speed is as high as 2600 rpm., whereas in the larger compound types the spindle speed is as low as 36 rpm.

The power of these drills varies, of course, with the air pressure, but it is astonishing to see how rapidly they work and what enormous power they have. Their absolute flexibility lends them to all classes of work, and for general drilling, reaming, tapping, flue rolling or cutting out flues from old boilers, there is nothing which compares with them. Through their use it has been possible to introduce methods of construction in boiler shops which have worked a revolution in the cost of boilers.

In connection with railroad locomotive boilers, rules have been formulated which require the drilling of tell-tale holes in staybolts, and the small size pneumatic drills are the most desirable tools for this work or for cleaning out these holes as occasion requires.

Scaling tools for removing the scale from the inside of boilers are nothing more than small, light pneumatic tools striking a fairly light blow but having a very high speed and they can accomplish an enormous amount of work in a most satisfactory manner.

PNEUMATIC HOISTS, CRANES AND JACKS.

Pneumatic hoists and pneumatic geared cranes are largely used in boiler shops for convenience in handling the various parts entering into the construction of boilers in the different stages of their construction from machine to machine, and where air is available a considerable saving in labor can be effected through the use of these devices. The pneumatic cylinder hoist is a direct-lift type and can be furnished in capacities up to 20 tons and for any reasonable lift. Where this type cannot be used, the geared hoist is easily mounted on a hook and swung from a jib crane or may be arranged to travel on the under flanges of an I-beam trolley track. These can be obtained in standard sizes from 1 to 10 tons. They consist of suitable air motor and necessary gearing, together with a drum, all contained in a sturdy frame and suspended from hook or trolley wheels, as the case may be. They are a most desirable adjunct to any boiler shop, and with reasonable care have a long life and make a good showing in every way.

Pneumatic painting or paint sprayers may though not so great as some of the other devices mentioned. In principle they consist of a cylinder with a piston; a heavy piston rod projecting through the top head of the cylinder, the air being admitted to the bottom, the

Pneumatic jacks also have a useful field, alpiston moves upward exactly as in the case of a hydraulic jack. These can be obtained in stock sizes from 1 to 20 tons and prove themselves a very useful tool, either for permanent installation in some fixed place as an adjunct to a permanent machine or mounted on wheels for ready movement.

MISCELLANEOUS AIR APPARATUS.

Pneumatic forges for rivet heating or tool tempering are light and compact, hence readily transferable, and can be taken close up to where the work is being done, thus insuring hot rivets without burning. They are simple in construction, durable and very efficient, and eliminate any necessity for pumping or grinding a rivet forge.

Pneumatic grinders of several sorts can be obtained, and these are very desirable for finishing edges of plates, corners or for any other special grinding where it is desirable to take the tool to the work. They consist of a standard form of air motor, practically the same as that used in the pneumatic drills, with a suitable extension shaft for mounting on wheels which are made for either face grinding or edge grinding.

be used to considerable advantage in and around a boiler shop for painting boilers, tubes, etc., before shipment. In the hands of even an inexperienced operator they do rapid, economical and satisfactory work.

This review of a most comprehensive subject is incomplete, as a paper much longer than the present one could be written on any one of the tools mentioned. However, it is hoped that interest has been aroused and that discussion will be provoked which will bring out special uses and devices that our various members may have found helpful in connection with their own practice.

AN EARLY SAFETY VALVE LESSON

The following seems to have come over to us from the eighteenth century. The "steelyard" spoken of is of course the safety valve lever.

"When the weight was at the farther end of the steelyard, the force of the steam, being

then very strong, would lift it up, and the steam would go out at the valve rather than spoil the boiler. A man who knew naught of the nature of the boiler set about to run it, and thinking to make his work done the quicker, hung a heavy plumber's iron upon the end of the steelyard, the weight itself being in like manner at the very end. The result proved fatal; for the strength of the steam collected until its force rent the boiler with a mighty explosion, and killed the poor man by the pieces which flew asunder."

NOTES

Mr. W. L. Saunders, editor of COMPRESSED AIR MAGAZINE, will deliver the commencement address at the Colorado School of Mines, Golden, Colo.

The Peerless Air Check Valve, described in our April issue, is manufactured by the Trolley Supply Company, Canton, Ohio.

The amount of steam power used in this country is estimated at 27,000,000 horsepower. Of water power, 35,000,000 horsepower are said to be available, but only 5,000,000 has been developed.

The first annual national gas engine show, to include everything in gas power and allied lines, will be held in Milwaukee, June 17 to 22, inclusive, in connection with the convention of the National Gas Engine Association.

In the article "Tests of Turbo Compressors," page 6400, of our April issue, a 4000-hp. compressor at Johannesburg was described as having a "capacity of 1,250,000 cu. ft. of free air per minute" and an "energy consumption per 100 cu. ft. of free air of 0.301 hp." Comparison of other figures in the article shows that these statements should have read "1.250,000 cu. ft. of free air per hour" and "0.301 hp.-hr." respectively. Also an air pressure of 114 lb. was made to read 114,000 lb.

The first week of August has been fixed for the celebration of the centenary of the great Krupp works at Essen, Germany, which will be attended by the Kaiser at the head of a brilliant galaxy of his fellow-German sovereigns, generals, admirals and civic dignitaries. The Krupps have also decided to invite distinguished representatives of the steel and iron industry in all parts of the world, including several from the United States. A feature of the festivities will be a series of sham battles. Men armed with weapons of the era of the Emperor Maximilian I will make such headway as they can against an army equipped with modern rifles and artillery.

Recently mercury ores were discovered by a peculiar accident near Field, British Columbia. The manager of the Canadian Pacific Railroad hotel at Field found mercury in the hotel sink. At first it was supposed some one had broken a thermometer, but the event recurred, and finally an examination showed native mercury in the gravels of the stream supplying the hotel with water.

A great blast at Tenino, Wash., was made up of 45,000 pounds of black powder and 1,200 pounds of dynamite. The blast dislodged about one million tons of sandstone, which will be used on the government jetty at Gray's Harbor. The explosive was placed in two tunnels 150 and 186 feet deep and seven laterals of 50 feet each. It was fired by a battery 1,500 feet distant.

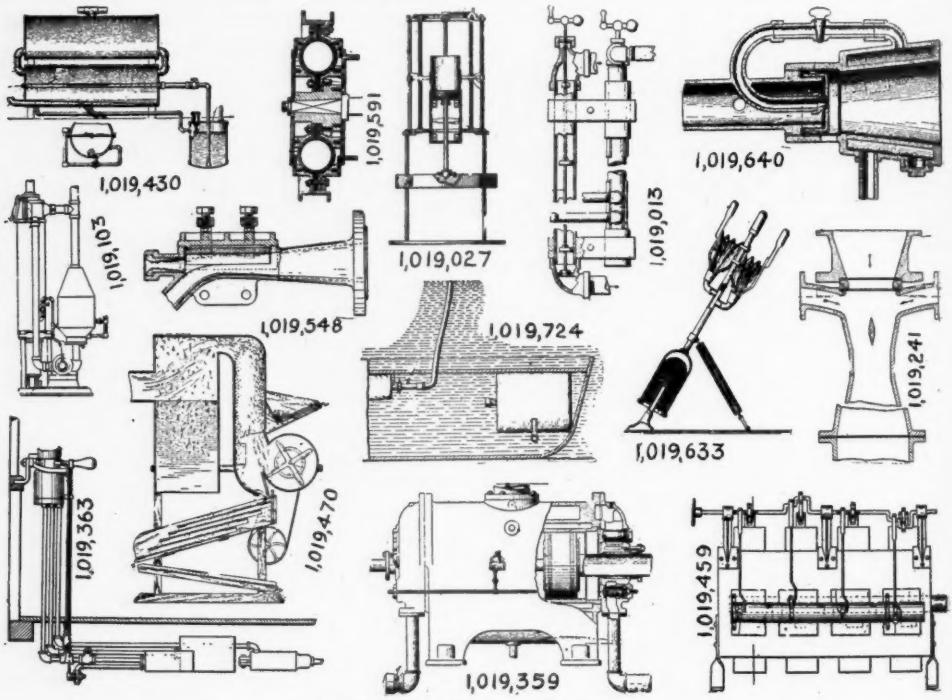
An average man of 150 pounds contains the constituents found in 1,200 eggs. There is enough gas in him to fill a gasometer of 3,649 cubic feet. He contains enough iron to make four ten-penny nails. His fat would make 75 candles and a good-sized cake of soap. His phosphate content would make 8,064 boxes of matches. There is enough hydrogen in him in combination to fill a balloon and carry him above the clouds. The remaining constituents of a man would yield, if utilized, six teaspoonfuls of salt, a bowl of sugar, and ten gallons of water.

The barbers in the cities of the Calumet region are having an experience of their own with Portland cement. They find that employees of the cement plants in these districts have concrete faces. The barbers claim that in the plants the cement dust settles in the men's beards, perspiration moistens it, and when they go out into the open air, it sets and faces are covered with concrete, reinforced by stiff whiskers. This takes the edge off the razors. Steps are being taken to invent a tonsorial sand blast.

Two shotfirers were recently saved at Radley, Kan., by means of a mine-telephone system. When the shotfirers were at work one evening, in the mines of the Girard Coal Co., an explosion occurred. The engineer at the surface, to whom the shotfirers reported from station to station as the blasts were set off, was able to direct the rescue party to the approximate location of the shotfirers, who were quickly taken out and resuscitated. This mine-telephone system thus not only saved the lives of these men, but from a purely business point of view, more than paid for itself in the elimination of damages that would probably have occurred in the event of these men not being rescued.

In Switzerland, water power is conserved and utilized to such an extent that in some towns not an ounce of coal is used. Power, light and heat are furnished by water power.

Every known explosive, if fired in a sufficiently large charge, will cause the ignition of an explosive gas mixture, but explosives have been found to differ widely in regard to the amount that can be fired without causing such ignition. Ordinary black blasting powder, for example, will cause the ignition of explosive gas mixtures very readily, as little as 25 gm. (somewhat less than an ounce) invariably serving to bring about this result. Certain other explosives, in quantities as great as 1000 gm. (2⅕ lb.), after repeated trials, under conditions exactly similar to those used in testing black powder, have invariably failed to cause ignition of the explosive gas mixtures.



PNEUMATIC PAT ENTS, MARCH 5.

LATEST U. S. PATENTS

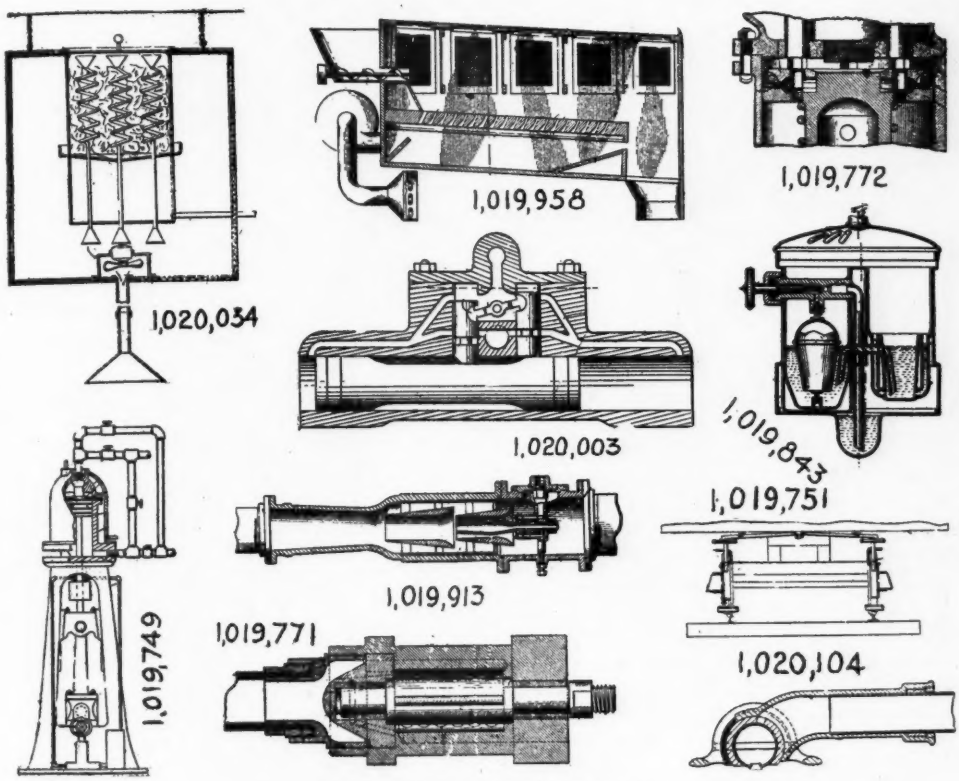
Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

MARCH 5.

1,019,013. BLOWER AND SHOWER FOR PAPER-MACHINES. OTTO BAKER, Piermont, N. Y., and EUGENE J. MCCARTY, Clinton, Mass.

1,019,027. WAVE-MOTOR. JOHN WILLIAM DENNY, Mapimi, Mexico.

1. In a wave motor, the combination with a supporting frame, of a compression cylinder supported by the frame, a piston in the cylinder having a depending piston rod, a float secured to the latter end of the piston rod, the undulations of the waves shifting the float and thus the piston to compress air in the piston, a frame secured to and depending from the cylinder, said



PNEUMATIC PATENTS, MARCH 12.

frame having a portion providing a guide for the piston rod, an abutment bar secured on the piston rod and lying within the frame, and resilient abutments carried by the cylinder and by the frame for engaging said bar to limit the movement of the bar and thus the piston in either direction.

1,019,103. LUBRICATING SYSTEM AND APPARATUS. FRANK W. VAN NESS, Milwaukee, Wis.

1. The combination with a vacuum system of a pump for creating a vacuum therein, an oil supply chamber the upper part of which is in communication with the vacuum system, and an oil reservoir which is in communication with said oil supply chamber and in which reservoir the oil is subjected to a greater pressure than the pressure which exists in the vacuum system when the pump is in operation.

1,019,135. PNEUMATIC FLOOR - OILER. CHARLES W. COREY, Malden, Mass.

1,019,241. HYDRAULIC APPARATUS FOR EXHAUSTING OR EXTRACTING AIR, GAS, OR VAPOR. WILLIAM JOHNSTON FRAME, Glasgow, Scotland.

1,019,359-60. UNLOADER FOR FLUID-COMPRESSORS. WILLIAM PRELLWITZ, Easton, Pa.

1,019,361. MOUNTING FOR AIR - FEED DRILLS. WILLIAM PRELLWITZ, Easton, Pa.

1,019,363. RAILWAY PNEUMATIC APPARATUS. JAMES R. RICKETTS, Los Angeles, Cal

1. In railway pneumatic apparatus, a compressed air supply, a container for partially spent compressed air, a controller for directing compressed air from the compressed air supply to brake actuating mechanism and for directing partially spent compressed air from such brake actuating mechanism to said container, and means for passing partially spent air to the open atmosphere at a point between said controller and said container; said last named means being actuated by the handle member of the controller.

1,019,430. METHOD OF CARBURETING AIR. ROBERT C. DAWSON, McKeesport, Pa.

1,019,459. AIR-MOTOR. IRA L. GRINNELL, Detroit, Mich.

1,019,470. GRAIN-CLEANER. THOMAS O. HELGERSON, Minneapolis, Minn.

1,019,499. POSITIVE-PRESSURE BLOWER. HOWARD S. LEVY and GORDON H. BRANDES, Philadelphia, Pa.

1,019,548. SUCTION DEVICE FOR DUST-LADEN AIR. KARL SPITZER, Vienna, Austria-Hungary.

1,019,591. PNEUMATIC HUB. CHARLES EDWARD DE BOOS, Temora, New South Wales, Australia.

1,019,633. VACUUM-CLEANER. MICHAEL D. HADJISPIRIDIS, New York, N. Y.

1,019,640. OIL-BURNER. LEO MICHAEL HENNESSY, Providence, R. I.

1,019,724. DEVICE FOR RAISING SUNKEN BODIES. JOSEPH POLIZZI and FRANCIS WARREN CALONGNE, New Orleans, La.

MARCH 12.

1,019,749. COMPRESSOR. JOHN B. BENDER, Toledo, Ohio.

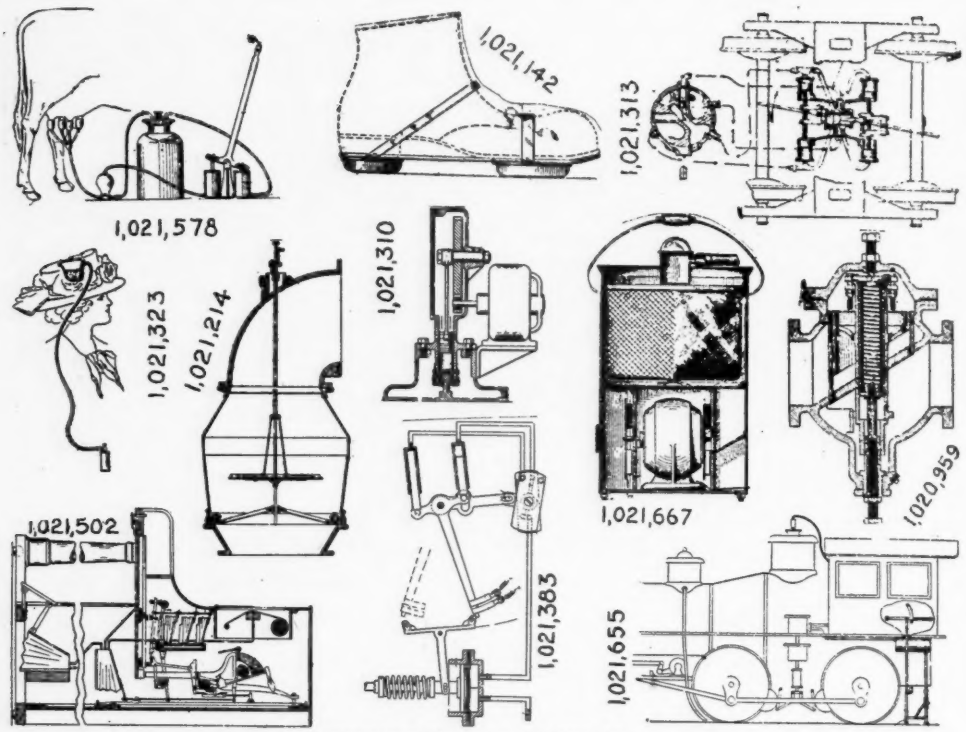
1,019,751. DERAILMENT AIR-BRAKE. EUGENE N. BOTSFORD, Platteville, Wis.

1,019,771. ROTARY MOTOR. WILLIAM S. ELLIOTT, EDWARD R. MILLS, and HARRIS B. HOLT, Pittsburgh, Pa.

1,019,772. METHOD OF LUBRICATING PNEUMATIC MACHINERY. EDWIN A. EMERY, Cripple Creek, Colo.

1,019,787. MOUTHPIECE FOR OZONE-MACHINES. ROBERT P. GUILEY, Akron, Ohio.

1,019,842-3. AIR-MOISTENING DEVICE FOR



PNEUMATIC PATENTS, MARCH 26.

HEATING APPARATUS. WILLIAM A. RUSSELL, Waterbury, Conn.

1,019,818. VENTILATING APPARATUS. FRANCIS JOSEPH MCMURDIE, Detroit, Mich.

1,019,913. PRESSURE-TRANSFORMER. WILLIAM H. PEARCE, Chicago, Ill.

1,019,958-9. SUGAR-DRIER. WILLIAM H. HANNAM and WARREN E. MURRAY, San Francisco, Cal.

1,020,003. VALVE MECHANISM. JAMES EDWARD WILLIAMS, Bessemer, Ala.

1,020,034. AIR-COOLING APPARATUS. FELIX FRANK, Cleveland, Ohio.

1,020,102-3. PROCESS FOR SEPARATION OF HYDROGEN FROM GASEOUS MIXTURES. CARL VON LINDE, Munich, Germany.

1,020,104. VACUUM-SWEEPER. FRANK J. MATCHETTE, Milwaukee, Wis.

1,020,241. PUMP FOR VACUUM-CLEANERS. CHARLES G. WIBORG, Galesburg, Ill.

1,020,310. VACUUM-CLEANER. WILLIAM H. RAKESTRAW, Bloomington, Ill.

13,384. (Reissue.) PNEUMATIC APPARATUS. JOSEPH SCHWERTNER, New York, N. Y.

MARCH 19.

1,020,619. VALVE MECHANISM FOR PNEUMATIC TOOLS. VINCENT J. O'BRIEN and ROMEO C. AWKERMAN, Denver, Colo.

1,020,852. APPARATUS FOR COMPRESSING AIR AND OTHER FLUIDS. WALTER B. SWINDELL, Raleigh, N. C.

1,020,859. WHISTLING-MACHINE. EDWARD VANDERALI and JOSEPH LITMER, Adrian, Minn.

1,020,893. SOLID LUBRICATING COMPOUND FOR COMPRESSED-AIR APPARATUS. EDWIN A. EMERY, Denver, Colo.

1. A solid lubricant having a moisture soluble surface and adapted to be transported to pneumatic machinery by air currents containing moisture, comprising moisture soluble solid soap, glycerin in quantity to render the product non-refrigerant and non-drying, lubricating oil to render said product resisting to penetration of moisture and a powdered mineral lubricant for the purpose specified.

MARCH 26.

1,020,959. PRESSURE-REDUCING VALVE. EDWIN J. BEST, Ensley, Ala.

1,021,142. PNEUMATIC WALKING ATTACHMENT. MALCOLM W. FREEMAN, Millington, Mass.

1,021,214. GOVERNOR FOR AIR-COMPRESSORS. RICHARD H. RICE, Lynn, Mass.

1,021,310. AIR-PUMP. HERBERT J. HAWTHORNE, GUY B. WYATT, and OTTO P. WARNER, Cleveland, Ohio.

1,021,313. RAILWAY-SWITCH CONTROLLER. PHILIP D. HIBNER, Seattle, Wash.

1,021,323. BUBBLE-HAT. ALDEN L. MCMURTRY, Sound Beach, Conn.

1,021,383. PRESSURE-REGULATOR. MARTIN V. SMITH, Hartford, Conn.

1,021,502. PNEUMATIC PIANO. WILLIAM G. BETZ, Chicago Heights, Ill.

1,021,578. MILKING-MACHINE. LEO D. DE LANEY and MATHIAS A. HOLTZBAUER, Belmond, Iowa.

1,021,655. APPARATUS FOR BLOWING SAND FROM RAILWAY-TRACKS. CHARLES D. BROWN, Washington, Ill.

1,021,667. VACUUM-CLEANER. JOHN J. DUFFIE, San Francisco, Cal.

1,021,700. PROCESS OF INCREASING THE RAISING POWER OF DRIED YEAST. PETER DIEDRICH HINRICH OHLHAVER, Sande, Germany.

4. The herein described process of increasing the raising power of dried yeast, which consists in exposing such yeast to the action of air artificially saturated with moisture for sufficient time to cause re-hydration of the dried yeast organisms.